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AMERICAN BREEDERS MAGAZINE

Published by the American Breeders Association

A Theory of Mendelian Phenomena
PROF. W. J. SPILLMAN

New Hybridization Method for Corn
DR. GEORGE HARRISON SHULL

Indian Cattle in the United States
A. P. BORDEN

Report of Eugenics Committee
DR. C. B. DAVENPORT

Breeding and Use of Tree Crops
PROF. J. RUSSELL SMITH

Hatching Quality of Eggs
DR. RAYMOND PEARL

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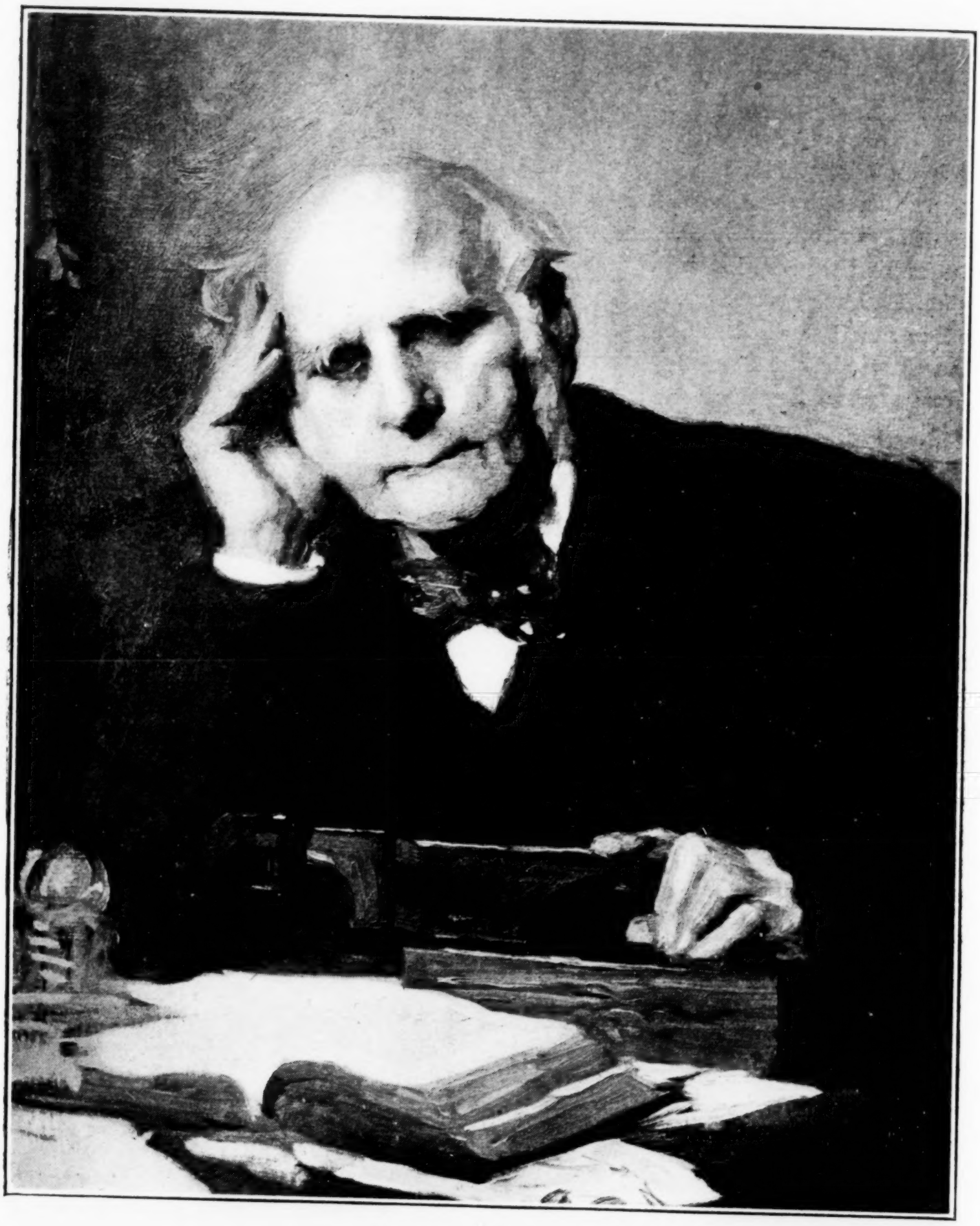


FRANCIS GALTON.

THE AMERICAN BREEDERS MAGAZINE

"Evolution ever climbing after some ideal good,
And Reversion ever dragging Evolution in the mud."—TENNYSON.

Vol. I. **Second Quarter, 1910.** **No. 2.**

HEREDITY: CREATIVE ENERGY.

The heredity values of specially bred strains of plants and animals are as real as the seemingly more concrete values of land or goods. Potent economic values run through generation after generation as persistently and as irresistibly as the river runs from its many springs to the sea. Unseen carriers of heredity determine whether the product shall be large or small, of high or low quality, lovely or homely. Their value to the nation is far above that of gold. Gladly we pay high prices for new "blood" in plants or animals because through the sure and potent agency of heredity the enhanced values continue during succeeding years. Heredity is a force more subtle and more marvelous than electricity. Once generated it needs no additional force to sustain it. Once new breeding values are created they continue as permanent economic forces.

GALTON, VILMORIN, AND WALLACE.

Francis Galton, Pierre Louis Francois Leveque de Vilmorin, and John H. Wallace stand as three prominent pioneers in the development of heredity and breeding. Galton is a great scientist whose crowning work was the introduction of statistical methods in the statement of human heredity values. His application of these methods to performance records and the distribution of "talents" in the human breed, has made possible the science of eugenics and placed it upon a practical working basis.

Louis Vilmorin is best known by his remarkable achievement of transforming the common beet into a sugar beet, making it the basis of a great temperate-zone industry. He also originated the centgener method of plant breeding.

John H. Wallace stands beside Louis Vilmorin in first comprehensively introducing centgener performance in the selection of breeding animals. He taught horsemen the value of the blood of sires and dams in the first and later generations of progeny, and also the value of authenticated records of performance made at trotting races. He taught the American breeders of live stock the centgener method of finding the projected breeding efficiency of those rare animals whose blood has a special value among the breeds of our live stock.

FRANCIS GALTON.

B. 1822.

Francis Galton belongs to the group of evolutionary scientists who during the last half of the nineteenth century extended the boundaries of science and opened up new domains of research. He is one of the great constructive scientists. Francis Galton studied medicine, graduating from Trinity College, Cambridge, England, in 1844. He spent several years in African travel, taking part in an exploration up the White Nile and also in southwestern Africa. He afterwards engaged in the study of meteorology and was the first to attempt to chart weather conditions on an extensive scale. He wrote a comprehensive work on meteorology.

However, his fame and success rest mainly on his researches in anthropology and eugenics. His writings on eugenics—and they are classic—have thrown open entirely new fields of thought and re-

PIERRE LOUIS FRANCOIS LEVEQUE DE VILMORIN.

search. It was he who first conceived the possibilities of eugenics as applied to the human family, and he was practically the founder of this new branch of science. The ingenious statistical methods which he devised for stating facts of heredity in man are coming to be employed in connection with plant and animal heredity. Concerning the law of "frequency of error," Galton declared that "if it had been known to the Greeks it would have been personified by them and deified." He established and endowed a laboratory of eugenics at the University of London, with research fellowships and research scholarships, and the excellent work proceeding from that institution is largely responsible for the rapidly growing interest in eugenics in Europe and in fact in all civilized countries.

PIERRE LOUIS FRANCOIS LEVEQUE DE VILMORIN.

1816-1860.

The Vilmorins who founded the great Andrew Vilmorin Company, of Paris, France, are decended from one of the oldest families in the province of Lorraine. The family is proud of its records, which are authentically traced back to 1633. It is particularly proud of its succession of men who have attained distinction in the improvement of the seed stocks of the agricultural crops of their country, benefits which, in the nature of things, are shared by the whole world.

The first plant and tree catalogue published in France was written by Philip Victoire de Vilmorin in 1771. He was one of the founders of the firm that later was to become famous. This catalogue contained the names and descriptions of hundreds of varieties of the world's medicinal, agricultural, garden, and ornamental plants and their proper mode of cultivation. This publication is said to have had a marked influence on farming in France.

The establishment passed from Philip into the hands of the son, Andree (1776-1862), who was at once student, worker, and business man. In 1843 his son Pierre Louis Francois Leveque de Vilmorin took charge of the business interests of the firm and carried it on until his death, which occurred in 1860, two years before the death of his father, Andree.

In 1866 the firm, then a great plant breeding establishment, passed into the hands of Henry, the son of Francois; and at his death in 1899 Philip, the son of Henry, became the successor in this re-

JOHN H. WALLACE.

markable line of descent whose men combined scientific and business attainments in a most unusual degree.

Pierre Louis Francois Leveque de Vilmorin, the subject of this sketch, originated, as stated above, that phase of statistical methods in plant breeding which uses performance records to determine the projecting power of parents through excellence manifested in their progeny. He dealt chiefly with two problems. One was to collect varieties of grains from all parts of the earth, and plant them for a general comparison, that he might select those with greatest value to the farmers of his country. The second was, by breeding, to discover from among the plants or varieties those which would give strains or varieties more useful than the original foundation stocks. His work in improving the sugar beet and making a commercial possibility of beet sugar gave his name an enduring place in history. A place in this trio of noted men is given him because, so far as the editors know, his work in sugar-beet breeding introduced the centgener method of plant breeding. He selected many roots the juice of which upon analysis showed, along with a large yield, a high percentage of sugar and a low percentage of solids other than sugar. Seeds from each of these roots were then separately planted. Out of the rows in which the roots showed a high yield of sugar and a high coefficient of purity he selected mother plants for the next generation for scientific breeding.

JOHN H. WALLACE.

1822-1903.

John Wallace's fame for his share in the work of creating the American Trotting Horse will endure as long as the harness horse is admired and used. His long connection with the American Trotting Horse Register, *Wallace's Monthly*, and the Trotting Horse Yearbook—creations of his own activity—and the handling of thousands of pedigrees and much horse-breeding literature gave him a peculiarly clear and extensive insight into breeding problems. In Volume II of Wallace's American Trotting Horse Register he gave expression to his ideas on breeding in an article of seventy pages on "How Should We Breed the Trotting Horse?" In that article was set forth for the first time so far as the editors have information, the use of the centgener method as a means for determining potent lines of descent

in animals. The application of this knowledge has been carried forward in a most remarkable way in the breeding of the Trotting horse.

John Wallace was born and brought up on a farm in Allegheny County, Pennsylvania. He left the farm at the age of 17 and settled at Muscatine, Iowa, in 1846. In 1848 he was chosen secretary of the Iowa State Agricultural Society. He compiled the pedigrees of American Thoroughbred horses and published only one volume. Then, his interest turned to the Trotting horse, and he published Volume I of the American Trotting Horse Register in 1871. Under very great difficulties he held to authenticated records and thereby placed the pedigrees of Trotting horses on an accredited basis, thus practically creating a breed of horses selected by means of performance records. Volume II of the Register was published in 1873-74. Some years later he sold his interest in the American Trotting Horse Register, in *Wallace's Monthly*, and in the Yearbook to the American Trotting Horse Register Association.

BREEDING AND USE OF TREE CROPS.

J. Russell Smith.

The United States interests us as the home of man, and our chief means of using it for that end are agriculture and forestry. In both of these fields we are very far from having attained any approach to perfection in the adjustment of our efforts to our resources.

As a step toward the better adjustment of our partly adjusted or at times maladjusted agriculture, I call your consideration to the value of tree crops—trees that live for decades or generations or even for centuries, but have their chief usefulness in the annual crop of fruit or nuts to use as forage for beast and food for man. These tree crops can in many places be profitably substituted for the annual crops that now dominate our agriculture to an injurious extent.

The scope and breadth of this scheme is a handicap to its easy execution. It involves not only plant breeding but much experiment in crop adjustment and farm management. It touches many fields of already organized enterprise, such as the national and state work in forestry, pomology, forage-plant investigation, animal husbandry, and farm management. It must be assisted by the entomologist, the students of fungi, and the specialists in technical research in that great field in which the state and national Departments of Agriculture work.

The possible material for the development of this class of crops includes all useful trees. The possible area of its usefulness includes all hilly land and probably some flat land as well.

I. *The first line of work suggested is the breeding of special strains of tree crops.*

Nature has produced numerous collections of trees each containing within hybridizing limits the most astonishing variety of qualities which we now know how, by breeding, to combine into rare parent trees that are the basis of the varieties of cultivation.

Some of the tree crops which may be utilized are as follows:

1. *Chestnu* [illegible] se supply both forage for stock and food for man. The wo[illegible]ld consist in (1) breeding new varieties—Japanese and hybrids between Japanese and American for sheep, hog, and cattle food, as all these animals eat these nuts greedily from the ground. Some nuts grow large as hen's eggs and trees are

prolific bearers, early bearers, and hardy. (2) Breeding better flavored selections and hybrids for human food. Several hundred thousand square miles of our eastern hills might be made nearly as productive as the corn belt. The Italian yield of chestnuts averages 12 bushels per acre. The price is always above that of wheat. The value of European mountain-side chestnut orchards equals acre for acre the Illinois corn belt.

2. *Walnuts.*—Breeding of new varieties—hybrids of American black, Japanese, Persian and Chinese. Small areas of moist fertile slopes totaling many million acres, east and south, might produce a nut nearly or quite as good as the Pacific Coast Persian walnut. Many persons regard the flavor of the American black walnut as highly desirable. Its shell needs breeding down.

3. *Hickories.*—Breeding new varieties for human food and pig feed—hybrids of shellbark (a much prized nut which even with a thick shell brings a high price); some western hickories (larger than a black walnut), and some Kentucky nuts with large meats, good flavor, and shells so thin that they can be crushed in the fingers. Moist mountain slopes and fertile corners might yield a nut as good as the pecan, all over the south, east, and north where the hickory grows.

4. *Mulberry for forage.*—Breed new hybrids, and experiment with existing ever-bearing mulberries as pig, sheep, and poultry food, during the whole period of summer months. It might be possible to utilize a total area of 700,000 square miles in the South and southeastern United States. Louisiana has shown a mulberry grove to be worth $12 or more per acre per year for pig feeding with no labor.

5. *Sugar maples.*—Breeding and search for superior varieties. It is almost certain that strains of great superiority may now be found and used as a basis for varieties high in sugar. It is also possible that sugar maple is amenable to improvement similar to that which has taken place in the sugar beet. The experiment should be tried. This species thrives from Maine to Indiana.

6. *Persimmon.*—Breed new hybrids, and experiment with existing varieties for pig, sheep, and poultry food during fall and winter months. The long adherence of this fruit to the tree gives it especial value after frost has incapacitated most other vegetation. As an automatic pig feeder the steady dropping of persimmons from Decem-

ber to March is hard to beat. At present it is a persistent tree weed that fattens thousands of opossums each autumn. For human food, already the Japanese have developed persimmons as large as peaches and of acceptable flavor.

7. *Oaks.*—The acorns in the oak forests of Europe have been fattening hogs ever since our ancestors wore clothes, and California farmers regularly gather and store certain acorns for forage. Improvement can be made through hybrids and selections for heavy acorn yielders. Hilly lands throughout probably one-third to one-half of the United States may be utilized.

8. *Beech.*—What has been said of the oaks applies also to the beech except that its range is narrower and more northern.

9. *Hazel nuts, filberts, pine nuts, etc.*—These offer inviting possibilities to the breeder who would create both forage and food crops.

10. *Foreign species.*—Careful work by agricultural explorers will reveal many species to combine with our own and add important qualities in this breeding. It is probable that there are many other types of tree crops that can be evolved, such as hillside basket wood, bush forage where grass will not do well, Japanese or other bush paper plants, etc.

II. *The second field of work is the adjustment of tree crops that have already been evolved.*

There are two camps of fruit growers: (1) The cultivators, whose policy works to the ruin of hilly land and tends to make fruit growing push out other cultivated crops on best land. (2) The sod mulchers, who grow good fruit in old pastures without the use of the plow. The latter group are heretics, but their scheme certainly works into the conservation movement and some of them are making good. Just how far and under what conditions, with what varieties, or what kinds of stocks it will work, it is impossible to say, but to work out its limits requires a vast deal of experiment running through several decades. It is possible that most of the fruit needed in the United States can be grown on hillsides without in any way eroding them. If this can be done it will be a great gain to our national resources, in which the hillside gully is making one of the most irreparable inroads. This problem can have much light thrown upon it by the careful study by well trained men of some hundreds or thousands of existing orchards in the United States today.

It is only because of the short view and preconceived notions that we depend for animal forage entirely on annual tillage crops and a few perennial grasses. Letting trees continue idle is like keeping geldings when you might have brood mares.

Forty shade trees down the lane may produce nothing but the grace of the elm or the well nigh worthless soft wood of the maple. After a little tree breeding is done, they may shower down each autumn 40 bushels of hickory nuts, walnuts, or chestnuts worth from $50 to $100 or even more.

Ten shade trees in your pasture may in the autumn drop only dead leaves; or they may be of varieties yielding a crop more valuable than the profits on 3 acres of pasture.

Your wood lot and your wind-break may yield an occasional pole, log, or load of wood; or it may have wood as a by-product, and have its chief yield in the form of pork, mutton, or poultry, or a directly salable nut.

Kafir corn and durum wheat have yielded great service to certain sections of the West, but the full development of tree crops during the next 40 years will render a service to some part of every State in the Union, and at least a dozen States have half or more of their area which is rebellious to the plow because of a rocky, rolling, or steep surface which increases labor, reduces the yield and will in time cause the whole hillside to wash away if plowed regularly.

I want to see the elimination of the countless millions of barren maples, cotton-woods, and willows, and their replacing by trees of equal hardiness, equal or better wood value, and useful annual fruitfulness.

Virginia mountain sides with sod-grown apple crops worth $200 net cash per acre, the profitable sugar orchards of rugged New England and the mulberry-fed pigs on the sandy hillsides of Louisiana should be the rule, not the rare exceptions.

Tree crops offer a practically virgin field for the plant breeder. The breeders of cereals have recently expressed hope for 15 or 25 per cent increase in production as result of their arduous labors. In the field of tree crops we have as a beginning an indefinite number of naturally developed parents with strong and useful characteristics fully developed and awaiting the hand of the hybridizer, who can thus give a harvest to hundreds of millions of acres of practically unused, or quarter used, or shamefully abused land. With these

crops the now practically abandoned hillsides can take their place beside the wheat fields of the West in their contribution to the welfare of the American people.

Then after the good varieties are bred up, their use needs systematizing so that the owner of the now useless or gullying hillsides may easily find out the proper hardy varieties and the proper proportion of his land to plant in nut, fruit, or sugar trees so that he may have the right succession of jobs in his reduced amount of farm labor, and also the best succession of workless harvests for his animals to walk around and fatten upon. In addition to increase of production of food and wood, this tree breeding fits right into the movement for the conservation of resources. It puts the binding tree roots into the hillsides where now the misplaced plow is the mother of gullies.

The gully, the destroyer of soil, is the worst of all resource waste because it is often the irreparable destruction of the one indispensable resource. If the forest is burned we can raise another; if we use up our coal and iron we may find substitutes; but there is no susbtitute for soil, from which we get all our food, our clothing and most raw materials of industry.

The gully, with its yearly harvest of millions of tons of down-carried, channel-filling mud, is the worst enemy of river navigation, and we are just beginning to appreciate the importance of river navigation.

Tree crops will further serve the conservation movement by controlling stream flow so as to aid both navigation and irrigation.

Two great handicaps that afflict this work are its slowness and unprofitableness to the individual who does the work.

If it were a new method of breeding animals some enterprising citizen of Illinois would be selling high-priced boar pigs in 5 years, and making a snug profit. A diligent plant breeder might in 10 or 20 years evolve new varieties of chestnuts, walnuts, and hickory nuts which could eventually be worth $50,000,000 per year to hilly West Virginia, but the original creator of all these varieties probably could not make $500 out of the lot. It is work which government, both national and state, must attend to. That alone is the reason why it has so long remained undone.

There is a great deal of work now being done along some of these lines by both State and Nation. I am convinced that it needs

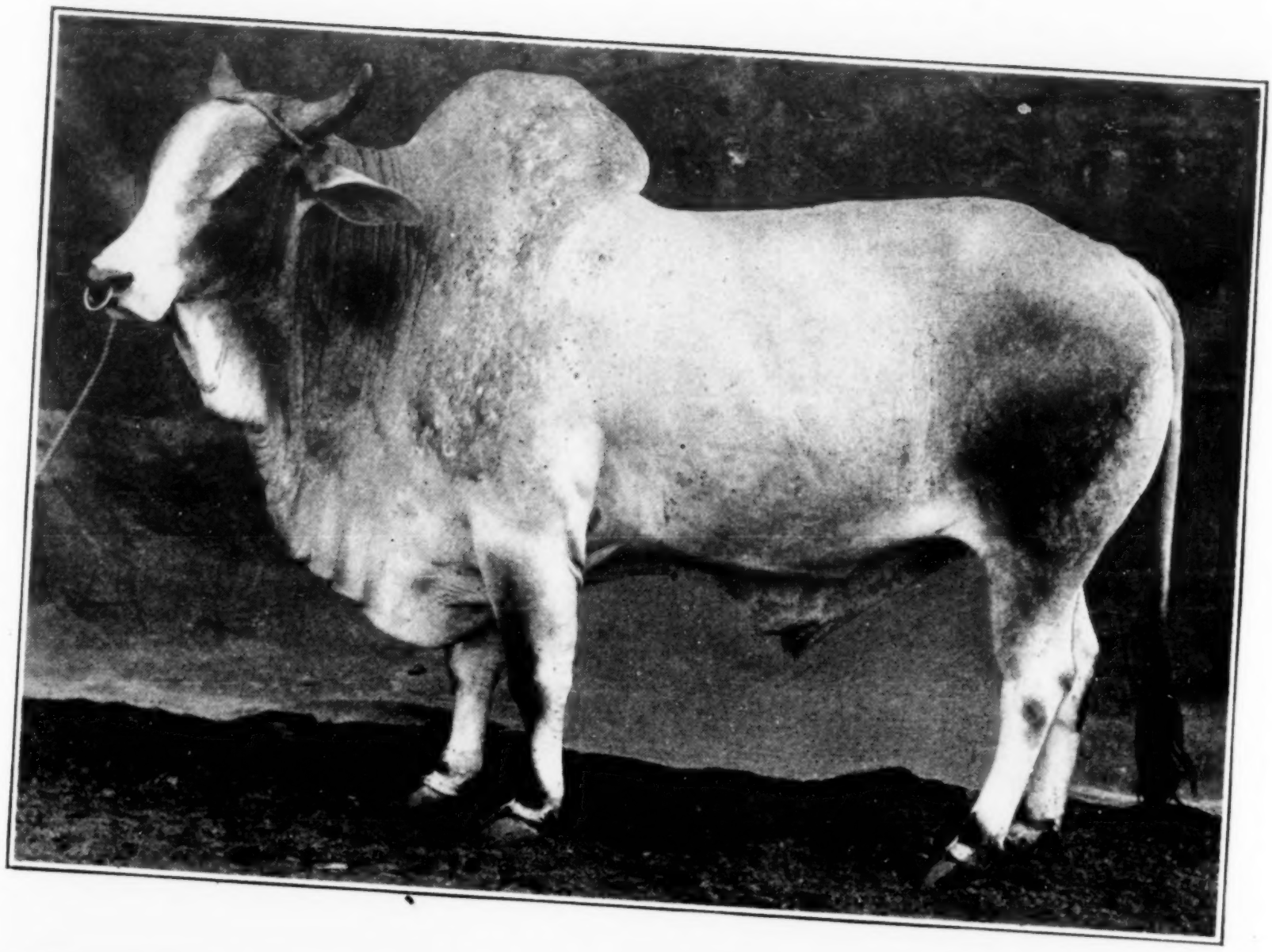
to be extended, strengthened, correlated, and directed toward definite problems. Just how this harmonizing of dozens of bureaus and institutions can best be done, I, as a layman, do not feel able to say. That problem is one for the existing state and national organizations to take up and I hope they will see fit to do so at an early date.

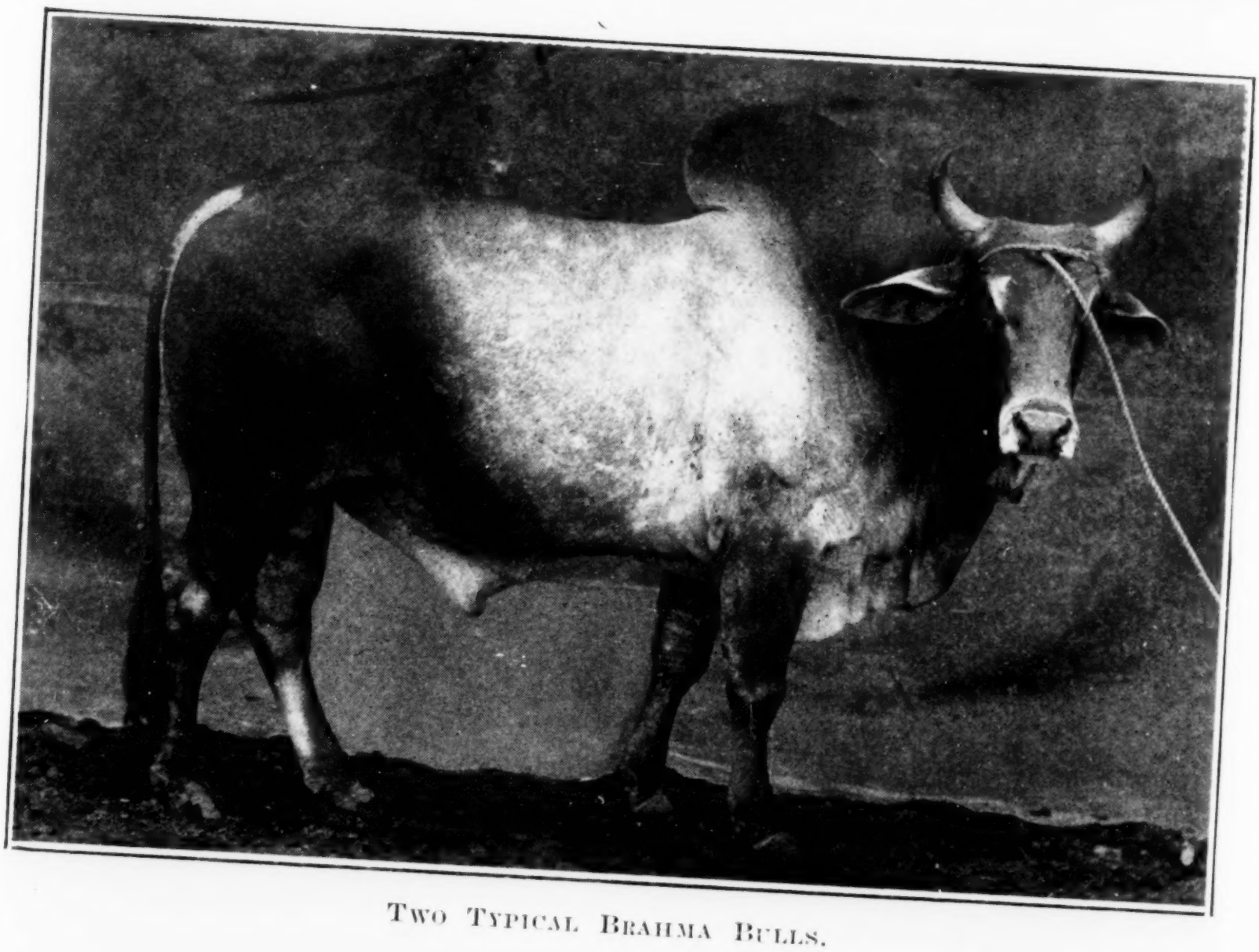
INDIAN CATTLE IN THE UNITED STATES.

A. P. Borden, *Pierce, Texas.*

The zebu or humped cattle of India form a distinct species and are scientifically classed as *Bos indicus.* Darwin in his work on animals and plants under domestication says that the zebu was domesticated as may be seen on the Egyptian monuments at least as early as the Twelfth Dynasty, that is, B. C. 2100. Some time in the early fifties a few animals of this breed, familiarly known as Brahma cattle, were brought into this country, and their offspring then distributed all along the Gulf coast. Observing stockmen soon learned that they stood the climatic conditions and insect pests better than any other breed. From time to time there has been a bull or two obtained from shows and added to the breeding herds of the Gulf coast country.

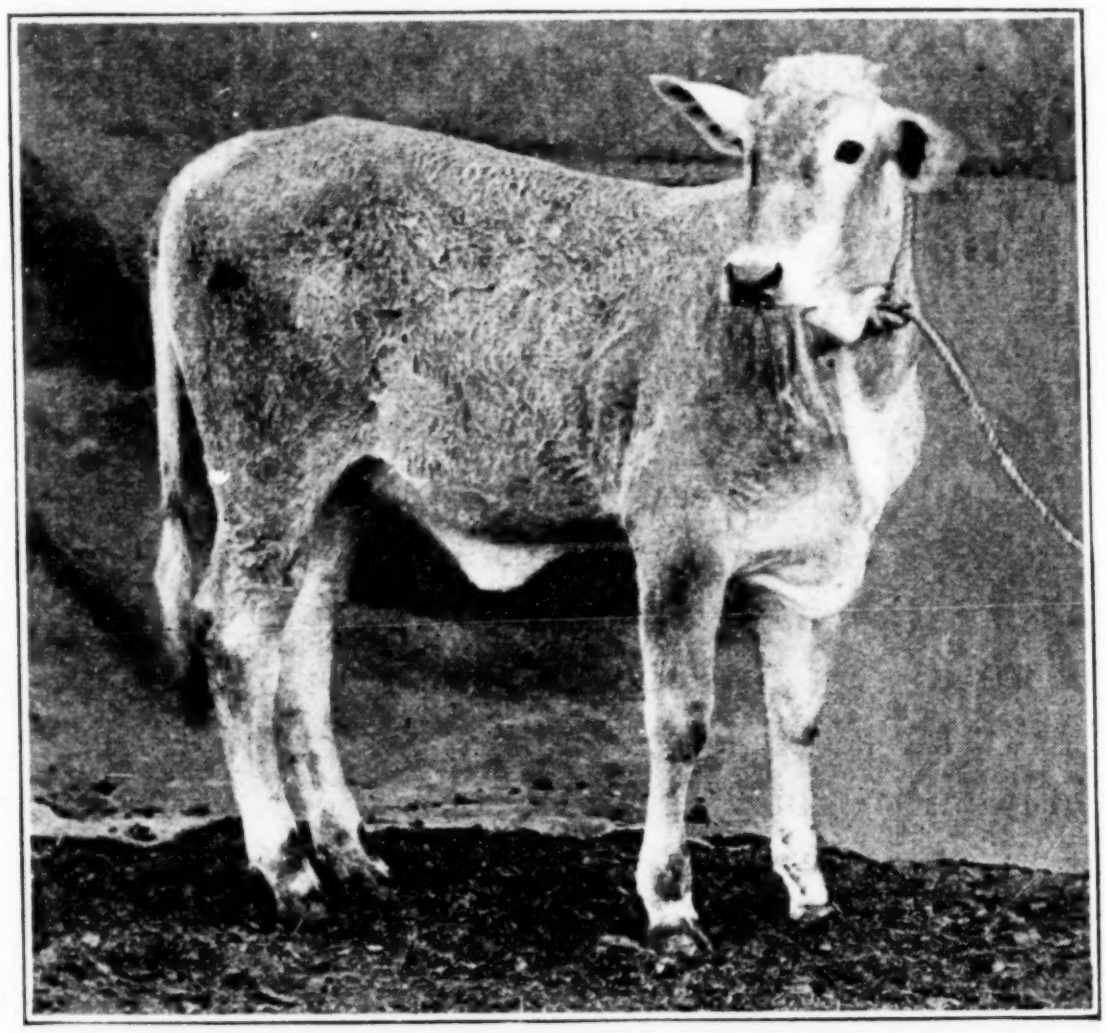
In 1904 Hon. James Wilson, Secretary of Agriculture, made a visit to Texas and after seeing the condition of the Brahma grade cattle as they then existed on the ranch of A. H. Pierce and comparing them with the beef breeds found on the same ranch had a special permit issued to A. P. Borden, executor of the estate of A. H. Pierce, for the importation of some purebred animals direct from India. The story of the permit for importation, my trip to India, the purchase of the fifty-one head of animals, their arrival in New York, their quarantine on Simonson's Island and their final release would make an interesting tale. The points of practical interest are that the cattle were bought with difficulty in India and could not there be tested. When put in quarantine on an island outside the harbor of New York, it was necessary to be at the expense of a long quarantine period to be sure that all brought to the mainland were free of the dread disease *surra,* which is even a more serious disease in horses than in cattle.





Two Typical Brahma Bulls.

This importation landed in New York in June, 1906, and in south Texas in November of the same year. It consisted mostly of young bulls. Upon arrival in Texas the cattle were first tested for Texas fever by Dr. Francis of our State Agricultural and Mechanical College. After carefully watching them for ten days he pronounced them to be free from Texas fever. This opinion proved correct, for in the three years since they were imported there have been no signs of this fever. The herd was divided as equally as



CROSSBRED CALF: BRAHMA (HISSAR) ON TWO-YEAR-OLD TEXAS HEIFER.

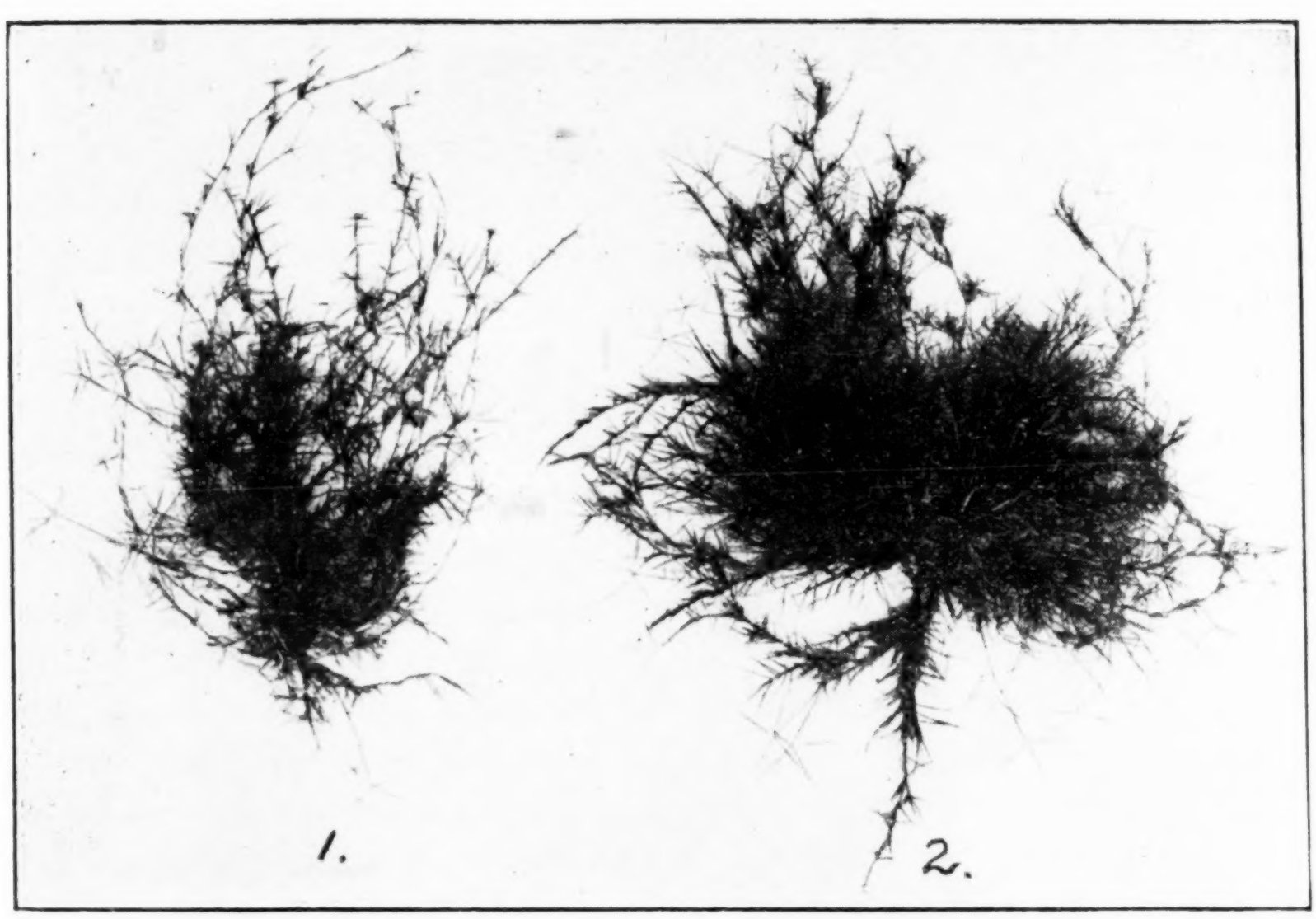
possible between Mr. O'Connor and the Pierce estate, who jointly had shared the expenses of the importation. I have not seen Mr. O'Connor's cattle, but he tells me they have more than met all his expectations. The object of the importation was to find a race of animals which would resist the insect pests of this section of the country, the principal one of which is the tick which causes Texas fever. These bulls were bred to the best cows on the Pierce range and to a bunch of Hereford cows in 1907 and again in 1908. The crop of calves in 1908 were fine and did remarkably well. We are in the business of raising cattle on the open range where they must care for them-

selves most of the year. Crosses of these native and grade cattle with the best European beef breed grades do well in the feed lot, yet for the range we find them delicate and susceptible to the ravages of the tick. To make a fair test of the Brahma cattle I turned the bulls on the range with the best cows I could procure in this section of the country, mostly high grade Herefords. These cows were covered with ticks all the year and as we had no dipping vats we had no way to remove them. We would occasionally find small ticks on the bulls, but were never able to find a fully developed tick on them. The first crop of calves at this writing, November 17, 1909, is from 14 to 20 months old. They have been in tick infested pastures with ticky cattle all their lives, but they fail to carry any ticks to maturity as far as I can see. It is only occasionally that we ever see a tick on one of these animals. This first crop of calves, about 300 in number, has grown upon the range as all our cattle and they are fully 50 percent heavier than our ordinary range calves. They are as heavy as the calves a year older out of the same mothers, but sired by purebred Hereford bulls. The crossbred animals are smooth, with very strong constitution, are good rustlers, of rapid growth, and are animals that have courage enough to look you in the face when you go about them. The results are better than I expected. It may be claimed for these cattle that they have the power of immunity from Texas fever. They stand a tropical and sub-tropical climate better than the other breeds of cattle. They have the power of transmitting the tick-resistant quality through several generations. An animal with only an eighth or a sixteenth of the Brahma blood in his veins shows ability to thrive in this climate. Several Indian breeds are represented in this importation. Some of these are shown in the illustrations herewith. I wish to state that I am under many obligations to Secretary Wilson and other officers of the Department of Agriculture and also to the Chairman of the Committee on the Introduction of Plants and Animals of the American Breeders Association, Mr. David G. Fairchild, whose letters of introduction and assistance were of service to me.

IMPROVEMENT OF BERMUDA GRASS.

L. A. Moorhouse, *Oklahoma Agricultural Experiment Station.*

Bermuda grass is a plant which has not been carefully studied from the viewpoint of the plant breeder; hence most of the fields that may be found in Oklahoma contain a large number of types which might properly be classified as varieties. Even areas which have been planted with the Hardy Bermuda, a selection that will stand comparatively low temperatures during the winter season, carry more than



Types of Bermuda Grass.

one type or variety, and in many instances these types have characteristics that are widely divergent. Inasmuch as improvement in plants which can be propagated by cuttings may be brought about by isolating individuals which have desirable forms and are known to be highly productive, it is certain that varieties of Bermuda grass, superior to the average mass or general planting, can be produced.

THE BASIS OF SELECTION.

Bermuda grass has several uses, and these should be considered in making selections for specific purposes. When this grass is to

be set on hillsides, on roadsides, or on pond banks, in order to prevent excessive erosion, a type which has a tendency to spread rapidly and one that has pronounced binding qualities should be singled out. For a pasture grass, a strain should be chosen which will start early in the spring, and it should continue to produce liberal supplies of forage throughout the growing season. Although Bermuda grass has been planted mainly with such objects as those mentioned, it can be grown for the production of hay, and varieties should be produced which grow tall and produce heavily of dry forage. Still other types may be developed for lawns or parks.

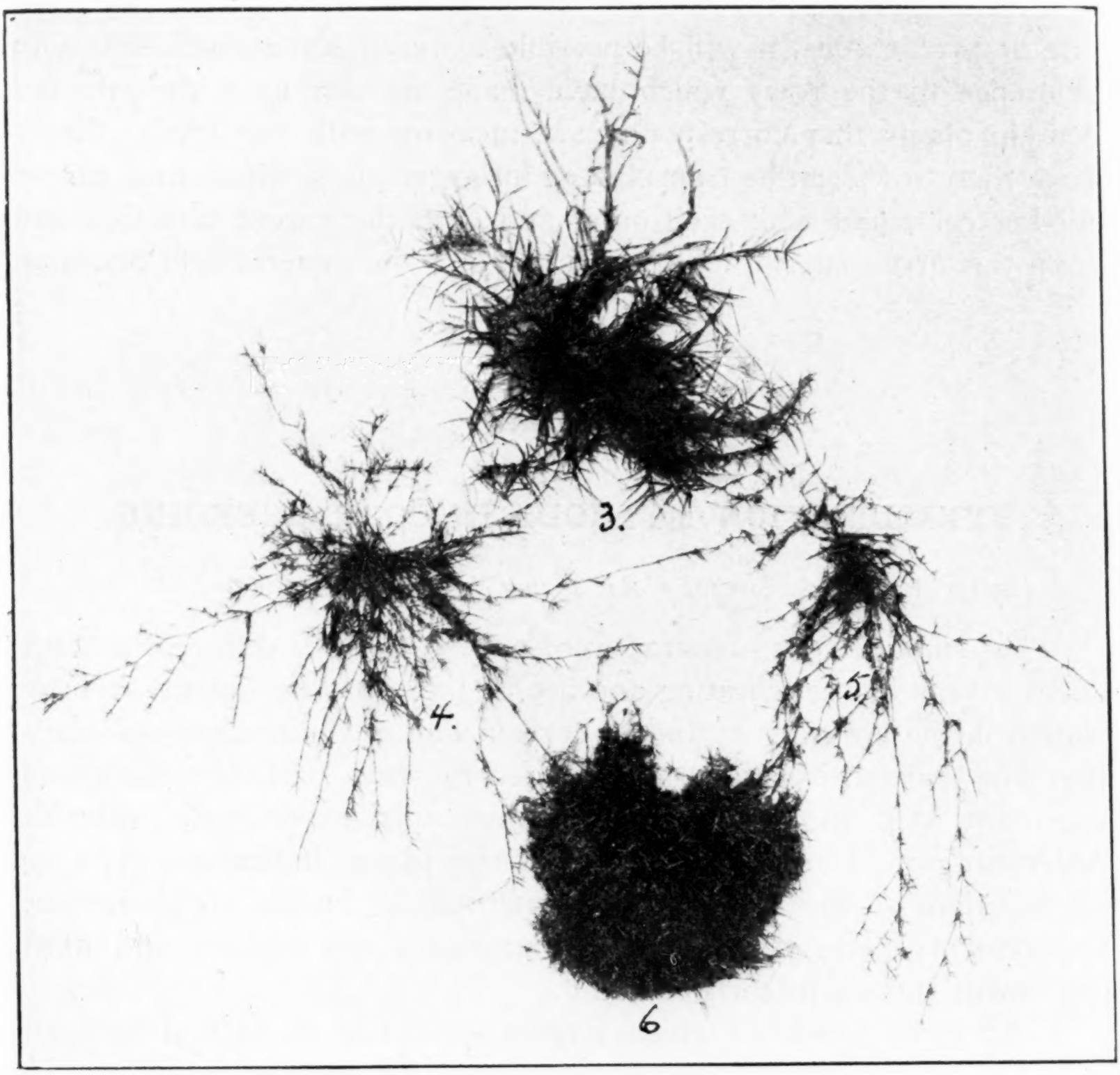
EXPERIMENTAL EVIDENCE.

During the summer of 1909 the Oklahoma station selected several distinct types and planted these types in separate rows for further study. While these varieties were started rather late in the season, and were, therefore, checked in their growth by the dry weather, the characteristics of the respective strains could be traced from the beginning of the summer down to the middle of October, at which time several plants were photographed. These types are shown in the accompanying figures. Plant No. 1 represents the spreading form and would undoubtedly answer well for soil areas which are subjected to washing. A splendid hay type is found in No. 2, which produced a very dense growth of upright stems or branches. Plant No. 3 differs from No. 2 in that the growth is not as dense and the stems are very coarse. Nos. 4 and 5 are extreme types of No. 1. They could not be used to advantage for hay, nor are they suitable for pasture fields. In Plant No. 6 we have a type which forms an exceedingly close turf, and with this characteristic apparently well establishd it ought to make a perfect grass for lawn or campus.

METHOD OF STARTING SELECTED TYPES.

The initial step in securing improved strains will include the selection of 100, or, better, a much larger number of plants which appear to have the proper characteristics. It will be well to thus choose mother plants from a number of fields, somewhat widely separated, choosing any varieties which may be known to have special value for heavy yield, hardiness in winter, etc. These are taken from the general field, and after the roots or portions of the stems have

been cut into small pieces, the cuttings, or "clons," from a single plant can be set in a row 25 or 50 feet in length, leaving a space of some 18 inches or 2 feet between the plants in the row. The rows should be located at least 4 feet apart; 5 feet would be a more suitable distance, especially in cases where the grass sends out long, creeping stems.



TYPES OF BERMUDA GRASS.

A nursery number is given to each mother plant, and the row planted from it is marked by that number. It is needless to recommend that the plantings be made on well cultivated soil. In fields which receive good cultivation the plants will certainly have a chance to come through the season in more vigorous form, and the contrast

between types ought to be greater under such conditions, thus affording an opportunity to isolate the more promising forms. It is not advisable to manure the land heavily prior to setting with grass, but some care must be exercised in choosing an area of uniform fertility.

PLANTING THE INCREASE PLAT.

After growing the nursery stock in the manner indicated for one or two seasons, it will be possible to reach some conclusion with reference to the rows which have made the strongest growth and contain plants that correspond in a measure with our ideal. Roots from these rows can be transplanted in larger plats, where they can be further compared with each other and with the parent varieties, and from this area material will be available for the general field planting.

HYBRIDIZATION METHODS IN CORN BREEDING.

GEORGE HARRISON SHULL, *Cold Spring Harbor, Long Island, N. Y.*

The simultaneous preparation of papers by three different authors about a year ago, advocating the use of more or less definite hybridization in the breeding of Indian corn in lieu of the methods of selection and partial isolation now in general use, probably marks an important step in the improvement of this exceedingly valuable American crop; for the appearance of these papers indicates a growing appreciation of the real biological nature of Indian corn and the requirements necessary to the attainment of the highest and most permanent success in corn breeding.

The three papers to which I refer are, "The distinction between development and heredity in inbreeding," by Dr. E. M. East, in the *American Naturalist* for March, 1909; a circular of the U. S. Department of Agriculture on "The importance of broad breeding in corn," by Mr. G. N. Collins, issued in June, 1909; and my own paper on "A pure-line method in corn breeding," read before this Association at its last meeting at Columbia, Mo., in January, 1909, and published in its last Annual Report. These three papers are in some

particulars fundamentally alike, but as they approach the subject from somewhat different points of view it will be interesting to compare them briefly.

The suggestion for a hybridization method in corn breeding is not entirely new. A very clear outline of such a method, with experimental results sufficient to warrant the suggestion, was presented by Morrow and Gardner in Bulletins 25 and 31 of the Illinois Agricultural Experiment Station in 1893 and 1894. These bulletins were evidently unknown to two of the three writers above mentioned,[a] and the third, Mr. Collins, while referring to Morrow and Gardner's bulletins, makes no statement of the fact that they had devised an adequate hybridization method for the practical utilization of the advantage shown by them to be sometimes attainable by crossing two distinct varieties.

In my paper on "The composition of a field of maize," read before the American Breeders Association in Washington two years ago, I pointed out the fundamental defect of the method now in general use, which simulates to a degree the isolation methods so successfully used in the improvement of small grains, and I suggested there that "continuous hybridization is perhaps the proper aim of the corn breeder." The conceptions which formed the basis of that paper were the complex hybridity of corn as ordinarily grown and the stimulating effect to heterozygosis or hybridity. It was shown that this stimulating effect comes into play in corn breeding because self-fertilizations result in the partial or complete isolation of many quite distinct strains, and that cross-fertilization must therefore result in the production of hybrid combinations of these pure strains.

My suggestion for a pure-line method in corn breeding was a direct logical sequel of this original paper on "The composition of a field of maize." Dr. East's article on inbreeding above mentioned is also a sequel to the same paper, as shown by his references to it and also by his excellent discussion of the stimulation which results from hybridity, in regard to which he has arrived at views identical with those entertained by me at the time my original corn paper was written. It may be said, therefore, that Dr. East's paper and my

[a] I am indebted to Prof. W. J. Spillman for calling my attention to these bulletins. Dr. East has informed me since this was written and read at Omaha, that he, too, knew of the existence of Morrow and Gardner's bulletins on corn, but was not aware that these authors had described a method for continuous hybridization in the culture of this crop.—G. H. S.

own have grown out of the conception, first presented by myself two years ago, that what may appear to be a uniform variety of Indian corn is really a series of very complex hybrids involving numerous distinct biotypes,[b] which may be isolated from their hybrid combinations by self-fertilization and which owe their smaller size and inferior yielding qualities, not to any injurious effect of inbreeding as such, but to the fact that self-fertilization gradually results in their reduction to a pure homozygous state. They are thus deprived of the stimulus which had been derived from crossing with other biotypes.

It appears that my paper of two years ago was unknown to Mr. Collins, although it was read in Washington and published in the Annual Report of the American Breeders Association in 1908. As Dr. East and I have both performed many experiments which have led us to place great confidence in the practical importance of the discoveries of Mendel, De Vries, and Johannsen, it is interesting to read in Mr. Collins's paper that these new results from the scientific side are "particularly dangerous" when applied to corn breeding. As Dr. East and I by the application of the newer biological conceptions have arrived at practically the same method which Mr. Collins recognizes as necessary for the best results in corn breeding, it should become evident to him that there is no such danger as he fears in the application of the latest scientific results to practical work.

The crossing of relatively homozygous strains or of distinct biotypes in corn in order to secure the stimulus of hybridity, as advocated by Dr. East and myself, involves a much more definite conception, however, than that suggested by the term "broad breeding." The idea of hybridization between distinct strains or between biotypes calls for the use each year of those two parental strains or biotypes which careful tests have shown to result in the greatest capacity for yielding an excellent F_1 (first generation hybrid) progeny. Although Mr. Collins advocates a method which is essentially identical with that proposed by Morrow and Gardner fifteen years ago and which has been invented anew by Dr. East, the idea of broad breeding would logically require the working in of a new variety or strain each year, instead of going back to the same relatively inbred strains for each successive crop. In other words, while Mr. Collins has suggested a splendid method of corn breeding, it is not one which corresponds

[b] A biotype is a group of individuals which do not differ from one another in any hereditary quality, and which therefore constitute a pure race.

well with the theory upon which he bases his suggestion. If the "broad breeding" idea is taken as a basis and a new variety is brought into the combination every year, it is plain that it must be done blindly, since the influence which this new variety will have upon either the quality or quantity of the crop cannot be known. However, the method advocated by Mr. Williams,[c] of the Ohio Agricultural Experiment Station, would overcome to a certain extent the blindness of this "introduction of new blood" by first testing its influence.

In the method of Morrow and Gardner, which, as we have seen, has been endorsed by East and Collins, involving the use of strains that, according to my experiments, are already complexly hybrid, there must be more or less resolution of characters in the resultant cross-bred plants, since the crop would not consist of F_1 plants with respect to all the numerous characters in which the two chosen parental strains differed, but would be, with respect to many of them, the F_2 (second generation hybrid) in which splitting up of characters occurs. The method which I described last year under the name of a "pure-line method" is the only one yet suggested in which all the plants in the resultant progeny would be first generation hybrids in regard to all the qualities which served to distinguish the parents. This does not prove, however, that my pure-line method is better than the method of Morrow and Gardner. It may be true, as Dr. East says, that the pure-line method is "more correct theoretically but less practical" than the method of Morrow and Gardner which he describes. It is conceivable that the method of using highly developed strains which have been produced by line-breeding and continual selection of the best and most vigorous ears may produce such high yields when crossed together that the expense and trouble of isolating pure biotypes will not be justified; but such a conclusion can be properly reached only as the result of extensive experimentation; and this experimentation, if undertaken in earnest by our State experiment stations, must result in the discovery of the best possible method for the breeding of Indian corn. My anxiety is not for the success of the pure-line method outlined by myself, but that serious experimentation shall be undertaken by every station within the corn-growing region for the purpose of discovering what is the best method. I feel quite

[c] Williams, C. G., Corn Breeding and Registration. Report American Breeders Association, 3: 110-122, 1907.

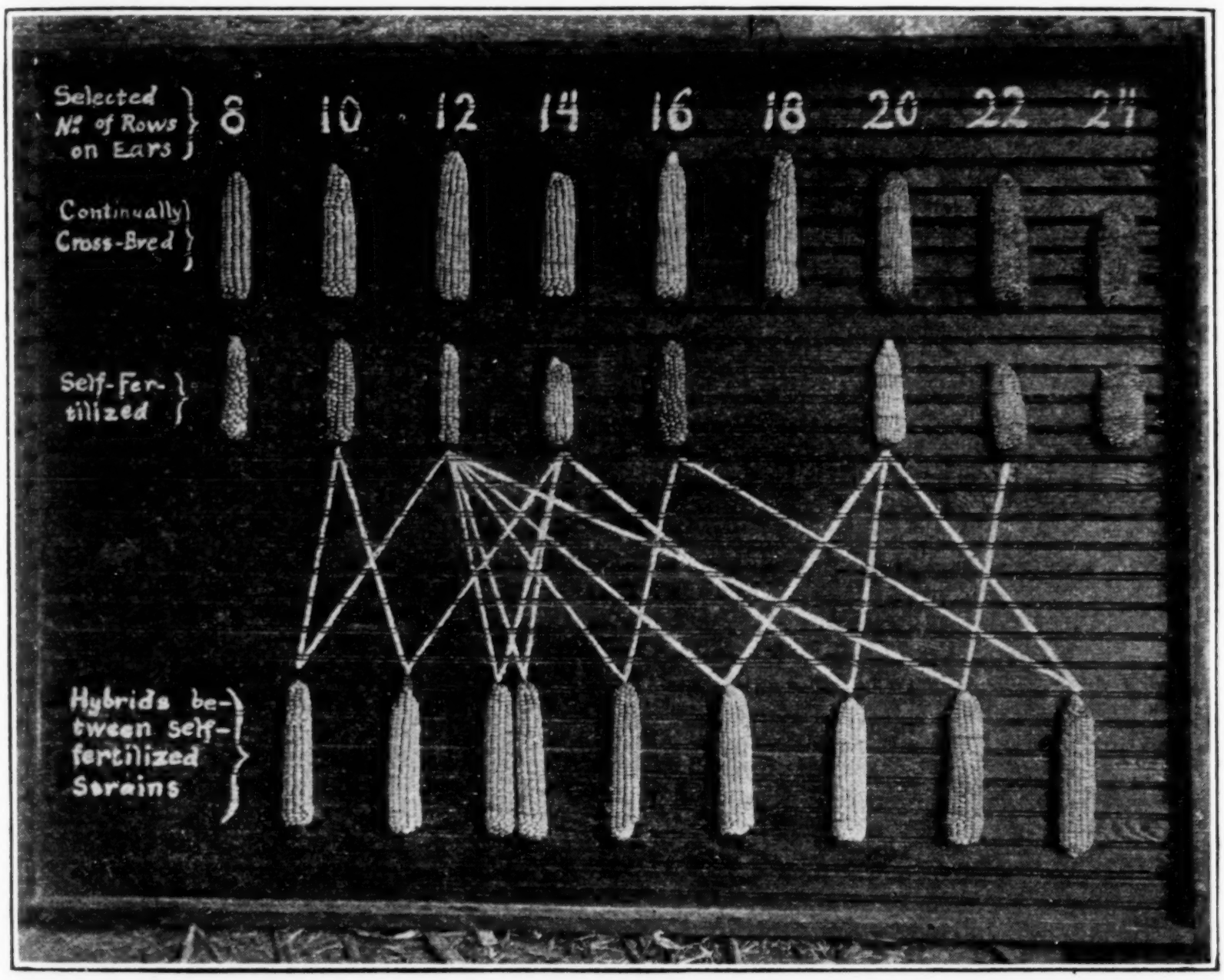
sure that the results of such investigations will lead to the adoption of some hybridization method in the breeding of this crop.

My experiments with corn during the last year have again given the fullest confirmation of my theories regarding the complex hybridity of the plants which compose an ordinary field of corn as grown at the present time; and data have also been secured having a direct bearing upon the applicability and importance of hybridization methods in corn breeding. Last year I presented the results of a single pair of reciprocal crosses between two self-fertilized strains which I called strain *A* and strain *B*. Those strains in hybrid combination produced a yield a little larger than the average of those families which had not been self-fertilized, but the difference was very slight. As strains *A* and *B* had been essentially unselected, being the first two self-fertilized strains which had become nearly pure-bred, it was anticipated that a larger number of crosses would discover some strains much superior to *A* and *B* as parents of a high-yielding F_1 hybrid progeny, as well, perhaps, as some which are inferior. This belief has been fully supported by the results secured in 1909, for in eight different hybrid combinations which were tested during the past season three have proved better than the combination between strains *A* and *B;* one other combination, also having strain *A* as one of the parents, gave a result about equal to that of *A* and *B*, and three combinations produced somewhat less than those of strains *A* and *B*. Not all of these hybrid families produced higher yields than the corresponding cultures which had never been self-fertilized, but the three highest yields produced in all my cultures were the result of hybridizing self-fertilized strains which had been, no doubt, reduced nearly to a homozygous (pure-bred) state. The average of all the hybrids when compared with the average of all the corresponding cross-bred[d] families shows the yield of the former to be only insignificantly lower than that of the latter, these averages being respectively 78.9 bushels per acre from the hybrids, and 79.4 bushels per acre from the cross-breds. This shows how effectively the cumulative "injurious effects" of five years of self-fertilization may disappear in a single year as the result of crossing.

The large yield of two of my hybrid strains as compared with the product of the best cross-bred families is not a mere chance relation, but is a specific function of the particular hybrid combination

[d] I use the term "cross-bred" here to denote those families in which all self-fertilization has been prevented during the five years these investigations have been in progress.

which produced them, as may be shown by two series of facts. In the first place, the hybrids between strains *A* and *B* which were reported last year as producing from 74.4 to 78.6 bushels per acre have this year yielded 79.8 bushels per acre. A slight increase in the other cultures for 1909 as compared with those for 1908 makes this slight increase in yield of the hybrid between strains *A* and *B* simply a measure of the better climatic conditions of 1909 as compared with



CROSS-FERTILIZED, SELF-FERTILIZED, AND HYBRIDIZED CORN.

The lines between self-fertilized and hybridized series indicate the parentages of the latter.

1908. The important feature of this result is that the F_1 hybrids between strains *A* and *B* maintain essentially the same yielding capacity in successive years, while other hybrid strains produce quite different yields, varying from 61.5 bushels per acre to 98.4 bushels per acre. This fact, therefore, speaks for the view that the yield is a result of the particular hybrid combination. The second fact which

supports this view is that reciprocal hybrids[e] give essentially equal results. Thus, strains *A* and *B*, between which reciprocal hybrids were reported last year as yielding 74.4 and 78.6 bushels per acre, respectively, produced this year, in reciprocal hybrid families, exactly equal yields, namely, 79.8 bushels per acre. More conclusive still is the result from my best hybrid combination of the past season which has also been tested in reciprocal crosses; see figure. These crosses were made between a self-fertilized strain which had been selected continually to 16 rows and another which had been continually selected to 20 rows of grains on the ear. When the 16-rowed type was used as the mother, a yield of 98.4 bushels per acre was produced; when the 20-rowed type was used as the mother, a yield of 96.1 bushels per acre was produced. If the production of 98.4 bushels per acre had been purely a chance result which might by equal chance have appeared in any other strain, it is scarcely conceivable that the reciprocal should have so nearly approached the same extreme yield. The lower of these two yields, namely, 96.1 bushels, is 8 bushels per acre above the best yield produced during the same season by any continually cross-bred family of corn in my cultures. From all the results reported in this paragraph, it may be safely concluded that the production of the highest yield requires simply the finding of the best combination of parents and then repeating this combination year after year.

Several new evidences of the correctness of my view regarding the hybrid character of any ordinary vigorous corn plant have resulted from the past season's work. The assumption that self-fertilization results in the isolation of pure homozygous strains or biotypes and that the real purpose of cross-breeding is to secure the stimulus which comes from the heterozygous[f] association of alternative qualities from the two parents, requires that the first generation of the cross between two pure self-fertilized strains be relatively uniform, and that the second generation, in which these various hybrid qualities are rearranged in every possible combination, shall show greater diversity. I have now reared two families representing the second generation of such a cross between strains *A* and *B*. The variation in the number of rows in self-fertilized strains, in F_1 hybrids, and in F_2 hybrids, are shown in the following table:

[e] Formed by using one variety as the male parent in one cross and in another cross between the same varieties using the other variety as the male parent; thus *A* x *B* and *B* x *A* are reciprocal crosses, and their progenies are reciprocal hybrids.

[f] Having each separate characteristic derived from only one of the two parents.

TABLE 1.—*Variations in number of rows of grains in self-fertilized strains, and in F_1 and F_2 hybrids.*

Strain	Number of plants having ears with—						Yield—bushels per acre
	8 rows	10 rows	12 rows	14 rows	16 rows	18 rows	
Pure strain *A*.	66	5	3				14.2
Pure strain *B*.			10	18	12		12.1
A × *B* (F_1)..		2	18	9	2		79.8
B × *A* (F_1)..		19	58	9			79.8
A × *B* (F_2)..	3	32	57	16	2	3	61.0
B × *A* (F_2)..		1	26	40	15	2	78.0

It is clearly seen that the F_2 ears show a greater range of variation in number of rows on the ear than those of the F_1. Since the empirical range of variation is capricious, and therefore is not a satisfactory measure of variability, I have calculated the mean, standard deviation, and coefficient of variation, for the numbers of rows on the ears of each of these six families. The constants thus derived are arranged for comparison in the following table:

TABLE 2.—*Mean, standard deviation, and coefficient of variation for number of rows on ear.*

Strain	Mean	Standard deviation	Coefficient of variation
Pure strain *A*....	8.297 ±0.055	0.705 ±0.039	8.498 ±0.474
Pure strain *B*....	14.100 ± .145	1.363 ± .103	9.664 ± .736
A × *B* (F_1)	12.710 ± .154	1.271 ± .109	9.998 ± .865
B × *A* (F_1)	11.767 ± .070	.956 ± .049	8.128 ± .421
A × *B* (F_2)	11.841 ± .110	1.733 ± .078	14.638 ± .671
B × *A* (F_2)	13.786 ± .108	1.464 ± .076	10.623 ± .559

It will be seen by noting the numbers in the last column that the inferences as to the relative variability of F_1 and F_2, drawn from the range of variation in the several families, were correct. This fact will be even more obvious if the coefficients of variation are averaged in pairs. In this way it may be found that these pure strains had an average variability of 9.081 per cent; their F_1 hybrids had an average variability of 9.063 per cent; and the F_2 hybrids an average variability of 12.63 per cent. My hypothesis requires that in the fertilization of the pure homozygous strains and in the production of the F_1 hybrids

between them equal sperms meet equal eggs, so that in each case the resultant offspring should be exactly equivalent in all their hereditary qualities and the coefficients 9.081 per cent and 9.063 per cent must be measures of the non-hereditary variations or "fluctuations," while the coefficient 12.63 per cent in the F_2 is the result of the concurrence of hereditary and non-hereditary variations.

The number of rows on the ear, which is used here as a measure of the variability, is not in itself of great practical importance, of course, but the general question of variability, which is illustrated by this character, is of very great practical value. The possibility of attaining a fair degree of uniformity in the several desirable qualities will favor a more definite specialization of the crop to meet particular desired ends. Besides, any diversity in the qualities of the crop necessarily means a lower value in regard to each desirable quality than would be attainable if all individuals were brought up to a uniformly high standard.

Another very practical point in regard to this second generation and which emphasizes the importance of utilizing the F_1 plants for the crop each year, is seen by a comparison of the yields per acre (see Table 1) produced by the F_2 as compared with F_1. In both of the F_2 families the yield is less than the corresponding yield of the F_1 families, and when taken together this difference amounts to 8 bushels per acre. When considered in connection with the increased variability, this serves to further illustrate the point made in the last paragraph, namely, that the increased range of variation means a decreased yield.

The results of all my investigations to the present time, which seem to demonstrate that there are many distinct biotypes of corn continually mingled together in complex hybrid combinations, and that there is a stimulating effect of heterozygosis, may be summarized in the following statements. The first four of these propositions were demonstrated by data presented in my paper on "The composition of a field of maize"; the next four in "A pure-line method of corn breeding"; and the present paper gives further proof of the correctness of (6), (7) and (8), and adds the last four.

(1) The progeny of every self-fertilized corn plant is of inferior size, vigor and productiveness, as compared with the progeny of a normally cross-bred plant derived from the same source. This is true when the chosen parent is above the average conditions as well as when below it.

(2) The decrease in size and vigor which accompanies self-fertilization is greatest in the first generation, and becomes less and less in each succeeding generation until a condition is reached in which there is (presumably) no more loss of vigor.

(3) Self-fertilized families from a common origin differ from one another in definite hereditary morphological characters.

(4) Regression of fluctuating characters has been observed to take place away from the common mean or average of the several families instead of toward it.

(5) A cross between sibs[g] within a self-fertilized family shows little or no improvement over self-fertilization in the same family.

(6) A cross between plants belonging to two self-fertilized families results in a progeny of as great vigor, size, and productiveness, as are possessed by families which had never been self-fertilized.

(7) The reciprocal crosses between two distinct self-fertilized families are equal, and possess the characters of the original corn with which the experiments were started.

(8) The F_1 from a combination of plants belonging to certain self-fertilized families produces a yield superior to that of the original cross-bred stock.

(9) The yield and the quality of the crop produced are functions of the particular combination of self-fertilized parental types, and these qualities remain the same whenever the cross is repeated.

(10) The F_1 hybrids are no more variable than the pure strains which enter into them.

(11) The F_2 shows much greater variation than the F_1.

(12) The yield per acre of the F_2 is less than that of the F_1.

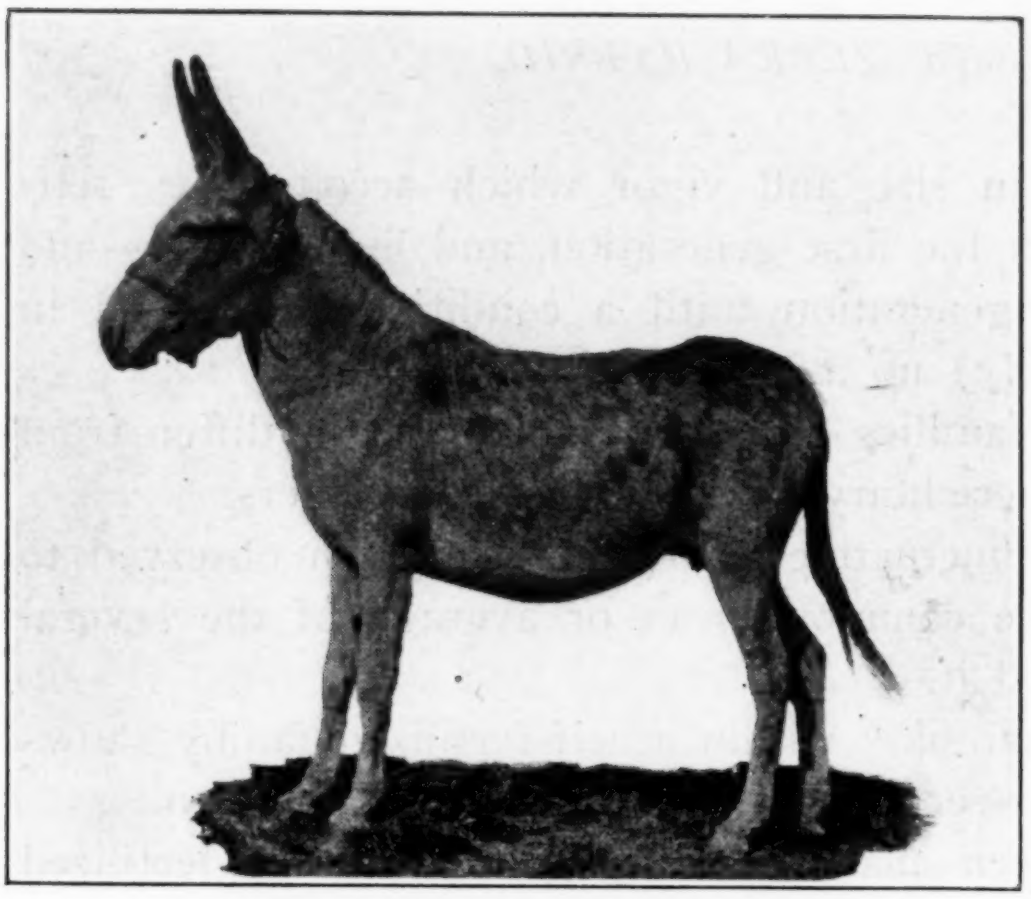
[Presented by Committee on Breeding Corn.]

A NEW ZEBRA HYBRID.

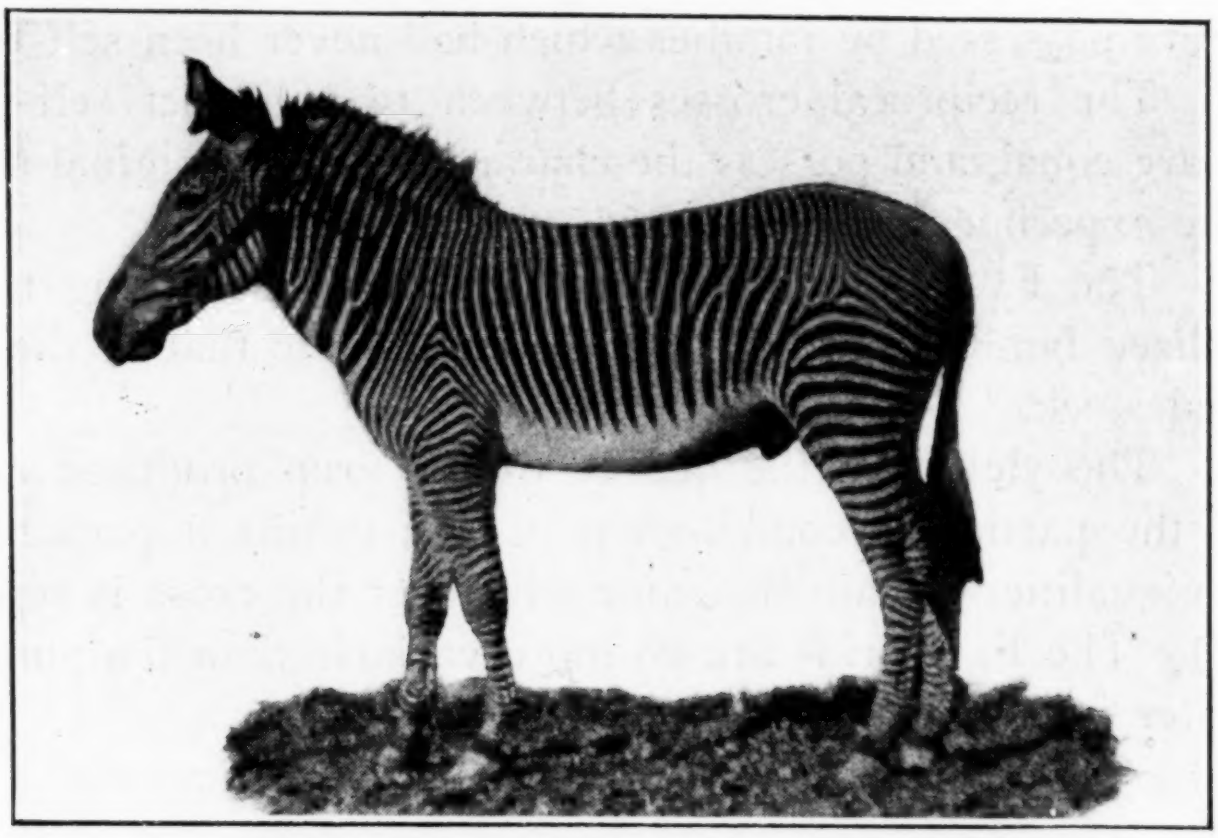
E. H. Riley.

During the past few years investigations relative to the production of new and useful zebra-hybrids have been in progress at the Experiment Station (Bethesda, Maryland) of the Bureau of Animal Industry of the United States Department of Agriculture.

[g] Sibs are brothers or sisters or both brothers and sisters, *i. e.*, they are the offspring of one pair of parents, without reference to sex.

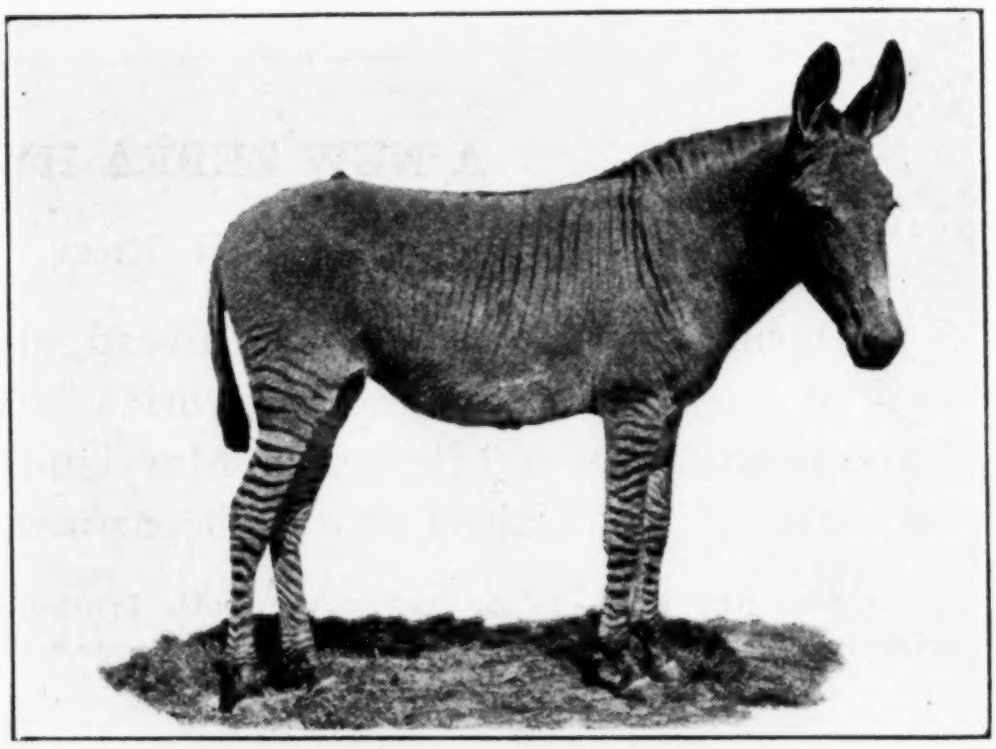


JENNY:
HEIGHT 12¼ HANDS,
WEIGHT 550 POUNDS.



ZEBRA STALLION: HEIGHT 13½ HANDS, WEIGHT 800 POUNDS.

ZEBRULE (HYBRID):
FIFTEEN MONTHS OLD,
HEIGHT 12¼ HANDS,
WEIGHT 500 POUNDS.



Zebra hybrid breeding is not a new line of work but has been carried on in foreign countries in a very limited way, with more or less success, since 1775. Some years ago Hagenbeck's Trained Animal Show exhibited two zebra-horse hybrids in this country which were said to have been bred by the owners, and later made use of them as work animals in connection with his show. The zebras used by these breeders were of the Burchell variety, which is among the smallest of zebras. These were mated with Shetland ponies.

The work of the Bureau of Animal Industry in producing zebra-hybrids is different from that done elsewhere in that the Grevy zebra *(Equus grevyi)* is being used. This variety of zebra is the largest and handsomest now in existence. The first one of this kind to be used in zebra-hybrid breeding work is a male about the size of a Kentucky jack—presented to President Roosevelt a number of years ago by Menelik, King of Abyssinia. This zebra was loaned by President Roosevelt to the Department for this experimental work, and was mated with donkey females. A number of resulting hybrids have since been foaled, the first of which arrived a little over a year ago. These hybrids are beautiful animals and seem to have combined the best qualites of both parents. They are much superior to either parent in conformation, disposition, style and action. The oldest, a male, was nearly as large as his dam when he was a year old. He is now being broken to harness and has been driven short distances to a light breaking cart. A filly, about a month younger than this colt, has made equally rapid growth.

There is a striking similarity between the species to which zebras and asses belong, which is quite apparent in their conformation, disposition, voice and action, the greatest apparent difference being in color, and in the size and shape of the ears. The ears of a zebra are much shorter and broader than those of a donkey. The markings of the zebra are uniformly striped black and white, while the donkey is of a solid color, many of them having a narrow stripe along the back and a stripe down over their withers, forming what is commonly known as the "cross." Considering these similarities, it is hoped that some of these zebra-ass hybrids may be fertile; this, however, will be tested at the first opportunity.

Since the work was begun, other zebras of the Grevy species have been imported from Abyssinia and are at present being used to increase the number of pure bred zebras as well as to get zebra-hybrids.

So far as known, Grevy zebras have never been domesticated. The zebras used in these investigations have been captured in their wild state, and have responded to civilization and kind treatment fully as well as horses that have been captured on our western prairies. An effort is being made to produce zebra-horse hybrids. A number of large mares have been selected for this purpose, and it is probable that hybrids of the mule type will soon be produced.

REPORT OF COMMITTEE ON BREEDING VEGETABLES.

W. W. TRACY, *Chairman.*

The work of breeding vegetables is practically very closely connected with that of seed growing, and its consideration may be taken up under three heads.

1. The organization of improved varietal forms better adapted to certain specific conditions and uses.

2. The identification of these different varietal forms, each under some generally accepted varietal name which shall stand for all plants of that varietal character, regardless of their origin.

3. The growing and more general appreciation of the economic value of stocks of seeds which will develop into plants, all of which shall be alike and typical of the sort.

The first line of work is generally the most attractive to the inexperienced seed breeder, and the results, either actual or supposed, are so attractive to the planter that the pr[illegible] find the most profitable branch of their [illegible] furnishing, at high prices, seeds of these "novelties," or supposedly new and improved sorts, each under some new name with loud claims of superiority but little of accurate description, so that the real character of the stock used may not be too generally known and the profit coming from the higher prices need not be divided with others. These conditions result in a rapid multiplication and constant change in varietal names without any corresponding change or real improvement in the stock itself. It often happens that so-called new varieties are practically identical in character with some preexisting sort which had dropped out of general cultivation because of some defect, which though not apparent, and only to be learned through experience,

made it of no practical value. Often so-called seed breeding is simply a wild chase after new things, "creations," with little regard to their real value. Crosses and hybrids are made with no more definite object than to secure variations in the hope that some of these may be new (to the breeder) and valuable simply because they are new. This course is scarcely wiser than for the hunter to fire without aim into a wood in which he thinks game may be concealed in the hope that some of the scattering shot may kill a partridge or a woodchuck.

In order that breeding for new varieties may be wisely done it is essential that the breeder should be fairly familiar with the greatest possible number of varietal forms which are or have been in cultivation. He should also know something of the practical value of varietal qualities, such as whether an increase in the crumple and frill, or a deepening of the yellow shade of the leaves of Grand Rapids lettuce would be an advantage, and, if so, why; whether a coarse or fine netting is the most desirable in melons of the Rocky-ford type, and why. All of his crossing and selection should be made either with the aim of securing some definite and practically valuable variation, or with the hope of securing increased vigor and vegetative energy without loss or change of varietal character. This last is often a most useful line of breeding, for the practice of close breeding in order to secure greater uniformity of varietal character often results in such loss of vegetative vigor that a "re-origination" of the variation by direct crossing becomes very desirable. To do this work wisely necessitates a careful study of existing variations and requirements [illegible] with them which should not be limited to a knowledge [illegible] characteristics, but should include such intangible qualities as hardiness and resistance to disease and drought, which are often most important factors in determining the practical value of a sort, and its adaptation to any particular conditions and requirements.

The second phase of the work, the exact definition and nomenclature of varietal forms, is of equal practical importance, for the want of definition and permanency in varietal forms and the names by which they are known is a great obstacle to real improvement. It is true that some varietal names have continued in popular use a long time, but in many cases there have been repeated changes as to the exact varietal characteristics the names stood for. Were

we to secure from the most reliable seedsmen samples of a score of different stocks all sold under some old and popular varietal name, the probability is that we should find that there were distinct varietal forms represented. Some of the samples would be quite uniformly of one form, others as uniformly of another, while some of them would be made up of a mixture of many; and if we secured samples of all the different named varieties of this vegetable offered we should be quite certain to find that many of these were practically identical with some old and well known sort. The disadvantage of this condition, at least to the seed user, is evident, though it may be a source of temporary profit to the seed dealers. This multiplication and confusion of names might be remedied through the work of some central and generally recognized authority which should clearly define each distinct and desirable variation. In order to accomplish this it would be necessary to have full, complete, accurate, and comparable descriptions of existing varieties and their adaptations to definite conditions and requirements. There is to-day no greater need in our horticultural literature than of more complete, accurate, and comparable descriptions of existing variations in our garden vegetables and their adaptation to definite cultural conditions and market requirements.

We turn now to the consideration of the third and really the most important and practically useful phase of seed breeding—the production of stocks which shall be uniformly of a certain desired type. The fundamental object of all vegetable culture is uniformity of product. Superlative individuals often actually lessen the money value of the crop. In most cases if the best, and the poorest one-fifth, of the plants in the field were uniformly of identical character with that of the intermediate three-fifths, the cost of culture and marketing would be lessened and the profit of the crop materially increased. The essentials of success in this line of seed breeding are very simple, and consist in the breeder developing a stock which is the product of the greatest possible number of generations of plants of *exactly the same varietal character,* rigidly rejecting all variant plants regardless of their individual value.

As to progress during the past year: No great principles or laws of plant growth affecting seed breeding have been discovered, and no material change in practice developed. There has been an increasing appreciation of the difference between the transmission and the expression of inherited tendencies, and that the former may be

operative for many generations without the latter, which may then be called out by favorable conditions. The more experienced seed breeders are giving increasing and more earnest attention to the practical usefulness of variations, and are breeding with more definiteness of purpose. Seed users are coming to a better appreciation of the importance of uniformity of varietal character, and the cry for new and improved sorts is slowly giving way to one for better and more uniform stocks of varieties of proven merit.

As to existing needs we think they are (1) more full, accurate, and comparable descriptions of varietal characteristics and their usefulness for specific conditions and purposes; and (2) the establishment of some generally acceptable tribunal which shall decide upon the varietal name by which each distinct and useful variation shall be known and whose decision as to name shall be accepted and adhered to in practice by both seedsmen and planters.

We recommend that steps be taken to secure the appointment of such a joint committee from our own association, the Market Gardeners' Association, and the Seedsmen's Association, together with representatives from the United States Department of Agriculture and the State experiment stations. To this committee all supposedly new sorts should be submitted and its report should clearly state the distinctive varietal characteristics of the stock.

[Presented by the Committee on Breeding Vegetables.]

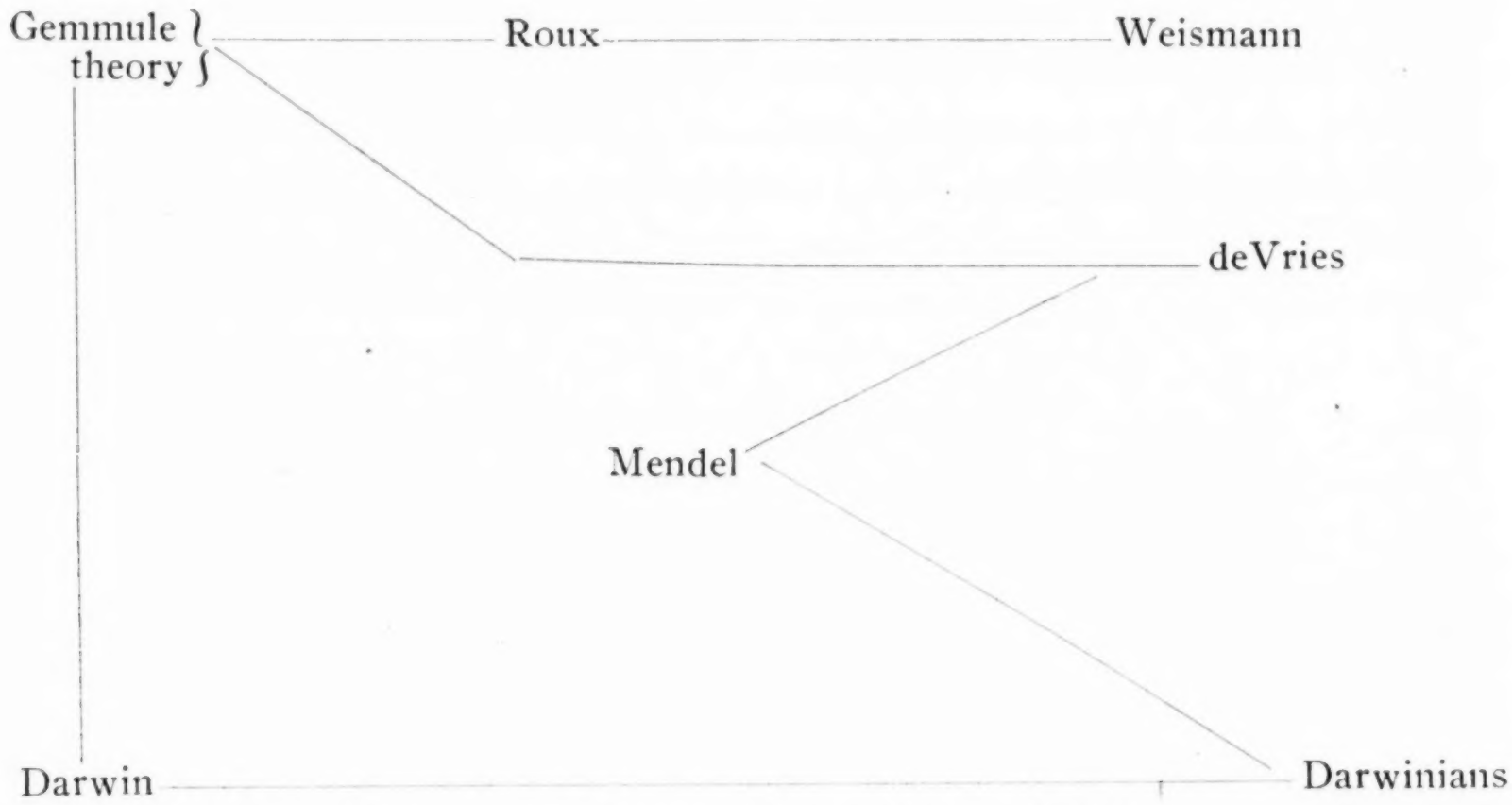
A THEORY OF MENDELIAN PHENOMENA.

W. J. SPILLMAN, *U. S. Department of Agriculture.*

Evolutionists are at present divided into two groups, one of which we may call the Darwinians, the other the deVriesians. In the latter class I include the adherents of Weismann. Strangely enough, Darwin is the father of both these schools. Little did he think when he propounded his gemmule theory, to account for the supposed inheritance of acquired characters, that he was laying the foundation for a philosophy of heredity and evolution which should well-nigh demolish his own theory of evolution. Yet this is what he did. It seems hardly possible that so fanciful a theory as that of the gemmules could ever have gained currency amongst biologists had it

not had the sanction of a great master like Darwin. Yet it has become the basis of the philosophy of evolution which is now very generally accepted, though the original hypothesis has been more or less radically modified. The deVriesian doctrine is based on essentially the same idea originally propounded by Darwin, with this important modification: it being generally admitted that acquired characters are not transmitted, that portion of Darwin's gemmule theory which represents each cell of the soma as giving off a gemmule, or bud, which makes its way into and becomes a constituent of the germ plasm has been discarded, and we begin with the gemmules in the germ plasm. The term gemmule is, of course, inappropriate to the new conception of these small hypothetical bodies, since they are no longer looked upon as buds from the somatic cells. Packed away in the germ plasm, their permanent home, they become pangenes, determinants, etc.

The historical relation between the present schools of evolutionary doctrine is shown in the following diagram:



RELATION OF PRESENT EVOLUTIONARY PARTIES.

The deVriesian school have seized upon the phenomena discovered by Mendel and recently greatly extended, principally by the deVriesians, because they believed they saw in them a confirmation of their theories. Generally speaking, the Darwinians have not given Mendelian phenomena much attention, rather conceding to the deVriesians their claim to them. Being distinctly opposed to the deVriesian

philosophy, and assuming that Mendelian phenomena favored that philosophy, the Darwinians have generally looked upon Mendelism with much suspicion, and some of them have even undertaken to question the authenticity of the facts of Mendelism. It is exceedingly unfortunate, in my opinion, that nearly everyone who has been instrumental in developing our knowledge of Mendelian phenomena has accepted the deVriesian view of them. It is also unfortunate that the Darwinians generally have so little knowledge of Mendelism that they continually mention it when they unquestionably mean deVriesianism. This is distinctly the case in the recent very important paper by Riddle. He boldly, and I think successfully, attacks the deVriesian position, calling it Mendelism throughout, and through his confusion of Mendelian fact with deVriesian theory he is also led into a determined attempt to rule these facts out of court.

On the other hand, Professor Morgan, a staunch Darwinian, has himself had a good deal to do with the development of our knowledge of Mendelism, and knows that Mendelian phenomena are stubborn facts. He is just as much opposed to the deVriesian interpretation of these facts as Riddle and he is casting about for another explanation of them. Prof. S. J. Holmes has also contributed a very valuable paper on the deVriesian philosophy, in which he points out the inadequacy of this doctrine, but in which he wisely refrains from trying to minimize the importance of the phenomena uncovered by Mendel. Unfortunately, some of the most conservative and most able of the Darwinians confuse Mendelian factors, which are demonstrated facts, with deVriesian pangenes, which are hypothetical cell organs with which it is attempted to connect the Mendelian factors.

We find that certain ontogenetic tendencies are transmitted from generation to generation. For instance, certain families of cattle develop black pigment in the hair and transmit the tendency to their offspring. In other families, we find the tendency to develop red pigment, and this tendency is hereditary. When we mate individuals from these two families, the progeny develops black pigment. If now we mate one of the cross-bred progeny with several red individuals, about half of the progeny are red and the other half black. Evidently, the cross-bred individual has transmitted the tendency to develop red pigment to part of his offspring and the tendency to develop black pigment to the remainder of them. It is these tendencies toward a

particular type of development that constitute the Mendelian factors. We can accept them as facts without giving allegiance to any paricular theory concerning the cause of them. That the two tendencies are present in the cross-bred individual can hardly be called in question. That these two tendencies remain essentially intact during their sojourn together in the hybrid is also hardly to be questioned. That neither tendency is permanently influenced by contact with the other is not definitely proven, though there is much evidence that, at least in the case of many factors, the hereditary tendency is not materially modified in such cases.

The theory of the purity of gametes is not at all essential to the interpretation of Mendelian facts, but it is a fundamental in deVriesian theory. I shall later attempt to show that the phenomena of segregation can be interpreted without recourse to the idea of "unit characters" at all.

The deVriesian position is succinctly stated by Nilsson-Ehle, in his recent important monograph, entitled "Kreutzungen an Hafer und Weizen," page 12, as follows: "That organisms are aggregates of independent units (Einheiten) is a conception which the investigations of Mendel and his followers have continually strengthened."

Belief that this statement is true has led many anti-deVriesians to become also anti-Mendelians. But, as Professor Holmes has pointed out, the above statement is not justified. I have elsewhere pointed out that the phenomena of the so-called elementary species, as well as those of mutation, are entirely consistent with the Darwinian conception of evolutionary change. Gates and others have found important evidence that the mutations found by De Vries are due to irregular distribution of chromosomes in the reduction division. De Vries himself has shown that these mutants differ from each other, not in a single characteristic, but in well-nigh every characteristic, which is just what we might expect if each of the chromosomes plays an important part in the development of the whole organism. If the hereditary characters are simply those properties of cell organs and tissues by virtue of which these organs and tissues have a determining influence in development, then evolutionary changes would result from those changes, either small or large, in the properties of cell organs and structures developed from cells by virtue of which they respond differently to their environment from what they did before, or by virtue of which they themselves change the internal conditions of the organism. Evolutionary change

would also result from change in the "personnel" of the chromosomes; that is, from loss, gain, or exchange of chromosomes.

In a short paper like this, it would, of course, not be expected that I should take up all the many Mendelian factors that have been demonstrated to exist, and show how the principles to be stated below apply to them. I will select a few representative cases.

Let us first consider the cross between red and white roses. The red coloring matter of the petals of the rose may be due to the continued action of a single enzyme on a single chromogen, the original chromogenic substance being first converted into another substance by the action of the enzyme, this second substance being further converted by the further action of the enzyme, and so on through a long series of reactions till finally a stage is reached in which the products of the oxidation process give color. Possibly the process is more complex than here supposed. That is, there may be more than two original substances concerned in the reaction. But in either case the final production of red coloring matter is a result of more or less complex processes.

Let us first suppose that the process is a chain of reactions between two original substances. Presumably, both of these substances are continually produced in the cell. The final stage reached in the reaction, it seems fair to assume, will depend on the relative amounts of the two substances entering the reaction. In red flowers we may assume that under the environment existing in the developing petals these relative amounts are such as to result in red color.

The ratio between the enzyme and the chromogen does not need to be definitely fixed. It is necessary, however, in flowers which are constantly red, for the ratio between the enzyme and the chromogen, under the assumptions here made, to remain within the limits of the red part of the chain, if we may so speak. In nearly related white flowers we must suppose that the relative amounts of enzyme and chromogen differ materially from those in red flowers. Perhaps the amount of enzyme is less, and as a result the oxidation does not reach the red stages. Recent investigations by Miss Wheldale indicate clearly that shortage of enzyme is responsible for lack of color in certain cases.

We have now to consider the reason for the difference of the ratios here assumed between the amount of enzyme and chromogen in red and white flowers. The assumed shortage of enzyme in the

white flowers might be due to the lessened production of enzyme on the part of one or many cell organs, either chromosomes or otherwise. But if the shortage is due to the general lack of production of enzyme on the part of all cell organs, then in the cross between the red and the white we should not expect any such definite segregation of developmental tendencies as we find in Mendelian phenomena. On the other hand, if the shortage is due to a single cell organ and that organ behaves in the reduction division as we know chromosomes do behave, in some cases at least, then we would get the usual Mendelian phenomena. It happens that in the case under consideration we do get segregation. The indications, therefore, point strongly to the assumption that in the case under consideration the difference between red and white flowers is due to the differences which relate to a single chromosome, or some other definite cell organ which behaves like a chromosome in the reduction division.

It should be observed that in the assumptions here made concerning the relation of cell organs to the development of red coloring matter we have no single organ which can be looked upon as the "determinant" of red in the deVriesian or Weismannian sense. Rather, the "determinant" of red is a kind of general function of the cell or of cell organs. On the other hand, in white flowers the phenomena of hybridization indicate that the failure to develop red color is due to a partial or total failure of a function of a particular cell organ, as a result of which the oxidation process does not reach the advanced stage met with in red flowers.

In the preceding we have assumed, with Riddle, that the final production of coloring material is the result of a chain of reactions between two substances. Unquestionably, many of the metabolic activities in organisms are more complex than this. Consider, for instance, the production of horns in cattle. Here we have produced, in the cells, under conditions existing locally in the organism, what is presumably a definite chemical substance. Unfortunately, we do not know the steps which preceded the production of this substance. From what little we do know about organic chemistry it is probable that the whole process of converting food into horn is a complex one and that several compounds are, at one time or another in the process, necessary. We may thus look upon the end result of a series of metabolic activities as being due to the interaction of a number of substances, in some cases the number being two, in others probably

more. We have also assumed that in cases where a chain of reactions occurs between two substances the ratio between the quantity of the two reacting substances originally present, or produced, may affect the stage reached in the reactions. Similarly, it is assumed that where a reaction is more complex, involving a larger number of substances, similar differences in the ratios of the substances present may give different final results.

In a species which is fairly uniform we must assume approximately a normal condition of metabolic activities of all kinds. Changes from this normal condition give aberrant forms. When the changes are due to changes of a single cell organ which behaves as the chromosomes do, then if the assumptions here made are true we necessarily get the phenomena of Mendelian segregation and recombination.

On this view we must look upon a pair of Mendelian characters not as simply units of an aggregate constituting the organism, but as different stages of an organism. Thus, in red roses, complex metabolic activities, in which any or all of the organs of the cell may participate, give us a particular result. In white roses, the same metabolic processes may go forward but in a manner different from that in red roses. Now if the difference in these complex processes be due to differences in the functions of a single chromosome, we then get the phenomena of segregation in the reduction division of the first generation hybrid entirely independent of any assumption of unit character. It might be fair, perhaps, to speak of unit differences, by which we mean the differences which relate to integral parts of the cell.

There are some cases for which, in order that they may be explained under the assumptions here made, we must assume rather complex metabolic processes. Take, for instance, the case found independently by von Tschermak, Locke, Shull and Emerson in certain bean crosses. They found that when certain non-spotted beans were crossed the hybrid seed was spotted. When this seed was planted 50 per cent of its progeny was spotted. The non-spotted seed produced only non-spotted, while the spotted seed again produced 50 per cent of spotted progeny, and this continued as far as the experiments were carried out. This points very clearly to the appearance of spots only on heterozygote individuals. On the other hand, all these investigators found other races of beans in which the spots were transmitted to all the progeny.

I would explain this case in somewhat the following manner: Let us assume that a single chromosome produces two substances, each of which is necessary in the more or less complex chemical changes that cause the production of the spots. Representing the chromosome by *M* and the two substances it produces by *a* and *c*, the symbol for the chromosome and its two functions relating to this character would be M^a_c. In a race of beans in which the chromosome in question has both of these functions in normal condition, all the gametes would have the formula M^a_c. But suppose that in a certain race of beans the function *a* becomes so changed that the resulting product can no longer perform its part in the group of reactions necessary. The somatic formula of individuals of this race would then be M_cM_c and the spots would be lacking. In another race we must assume that while the function *a* remains intact the function *c* becomes so changed that a necessary step in the production of the spots can not be accomplished, then we get another race with the formula M^aM^a. Now if we cross these two races we get a hybrid with the formula M_cM_a, which of course would have the spots. This hybrid would give us a progeny one-fourth of which has the formula M_cM_c, one-half the formula M^aM_c, and one-fourth the formula M^aM^a, which accords with the actual results obtained. If we should cross either of the deficient races with the race which has spots on all its seeds, the hybrid would have the formula $M^aM^a_c$ or $M_cM^a_c$. In this case the second generation would be three-fourths spotted and one-fourth non-spotted, a result which some of these investigators actually obtained.

Let us consider one other case, namely, that of the barring on the feathers of the Plymouth Rock poultry. Riddle has recently pointed out that in certain oxidizing reactions between tyrosinase and tyrosin certain stages of the reaction give black pigment. If the reaction be continued further white pigment results. The bars on the feathers of Plymouth Rocks, on this basis, are explained by an alternation of high and low rates of oxidization. Now it is known that this character behaves as a Mendelian factor. This indicates to me that it is due to some function of a single chromosome, or some other organ which behaves as the chromosomes behave. We may account for this alternation of high and low rates of oxidation by assuming that a single chromosome, under appropriate conditions in the organism, produces some substance that interferes with the activity of those organs in the cell which produce either the chromogen or the enzyme

required in this reaction. When this inhibiting material is present in a relatively large quantity, perhaps the amount of enzyme produced is comparatively small and we get the low rate of oxidation resulting in black pigment. But the inhibiting factor, acting upon the offending chromosome, reduces its own activity so that for a period of a few days less of the inhibiting material is produced. Meanwhile, excretory processes of the body remove this material or reduce its amount until finally the chromosome responsible for it renews its activity again. This mechanism would give us an alternation in rates of oxidation that would account for the white and black bars of the feathers. Many types of feather markings might be due to a process similar to that just outlined but operating locally in the body.

Here again, as in all the cases where we find Mendelian segregation, we must assume a more or less definite relation of a single chromosome to a given metabolic process. In no other way can we account for the phenomena of segregation.

In a somewhat similar manner we may explain the alternation of pigments found in the hairs of ordinary gray mammals.

In this connection I would suggest that since more than one kind of pigment is laid down at the same time it seems probable that we have to deal with more than one enzyme, or possibly more than one chromogen; but it is by no means necessary to assume an indefinite number of specific enzymes such as Riddle supposes is necessary to explain Mendelian phenomena. It is, however, necessary to assume for the chromosomes, or some other organs acting like them, as many definite individual functions as there are Mendelian factors.

In a few species there have been found more Mendelian factors than there are pairs of chromosomes, and some biologists have accordingly, and I believe without due consideration, assumed that this proves that the Mendelian factors can not be related to chromosomes as such. But this does not follow. I think it is probable that most of the chromosomes have functions which connect them more or less directly with every phase of development. Generally speaking, a Mendelian recessive will be due to the absence or latency or to a change in a particular function of a single chromosome. Now if a given chromosome has a relation to many characteristics of the organism, then we may have just as many Mendelian recessives depending on that chromosome as it has functions relating to development. In order, therefore, to demonstrate that Mendelian factors are anything other

than functions of chromosomes, it must be shown, in cases where we have more of these factors than there are pairs of chromosomes, that each of the factors is independent of all the others; that is, that any two of them may be transmitted together and may also be separated from each other. Both Shull and Baur have, in private correspondence, admitted the justice of this contention, and each of these indefatigable workers has planned to put this matter to test. It may turn out that Mendelian factors are not related to chromosomes as such, but I wish to call attention to the fact that as yet we have no evidence that definitely decides this point. On the other hand, we have a great deal of evidence in favor of the assumption.

For instance, the cereal rye has an exceedingly small number of chromosomes—six, I believe. In this connection it is interesting to note that rye is by far the least variable of all the cereals. But wheat has 40 or more chromosomes, and we have almost an indefinite series of varieties of this cereal. It should further be noted that the number of Mendelian factors that has been worked out for most species is less than the number of chromosomes concerned.

Of course, no one questions the great importance of the chromosomes in the economy of the cell. Some biologists do question whether these bodies maintain their integrity in all respects from generation to generation, but I believe I am safe in saying that everyone who denies the integrity of the chromosomes is an adherent of some theory which is favored by this interpretation. This is especially the case with the deVriesians.

I am confident that, whatever the relation of the chromosomes to Mendelian factors may turn out to be, these Mendelian factors are a reality and are due to some function of bodies which behave as the chromosomes do behave in the reduction division.

Most of the Mendelian terminology of the day is based upon the deVriesian doctrine of unit characters. If the view here presented proves to be correct we need some changes in our terminology. If we can not accept Nilsson-Ehle's statement that organisms are aggregates of independent units, we can not accept the idea of determinants developed by Weismann, and later by De Vries. Under the theory here presented the determinant of a character is to be sought in all those functions of cell organs which, by their combined action, result in the development of the character. On the other hand, the difference between two organisms may be due to the differences in single cell organs.

I am not sure that I have analyzed the facts here presented sufficiently to supply a terminology that will be satisfactory, and I shall not attempt to give a complete new terminology. We certainly need a word which means something different from the deVriesian definition of a hereditary character. Mendelian phenomena are based on hereditary differences, and I think that a Mendelian pair of characters can be fairly well described simply as a Mendelian difference. On the assumption that the metabolic processes in the organism are fairly complex, and that the development of any portion of the organism is a result of cooperation between many or all of the cell organs, we need to individualize the part played by definite cell organs in development. When a permanent cell organ has a function by virtue of which it affects the development of any morphological or physiological feature of an organism, I propose for such a body the term "teleomorph." This term is derived from the Greek "teleo" (make, accomplish) and "morph" (form or body). The part which the teleomorph plays in the development of any portion of the organism I propose to call the "teleone" of that teleomorph. Generally speaking, I regard a single teleone as one of a number, which, acting together, give rise to a final result. Thus, the pigment laid down in the coat of an animal may be the combined result of the interaction of a number of teleones. In a related animal which differs from the first in color, if the difference is due to a single teleone, and if the teleomorph in question is a chromosome, or other body that acts like a chromosome, then we get the phenomena of Mendelian segregation. But if the teleomorph in question is something other than a chromosome we should not get Mendelian segregation. Castle's work on the inheritance of size in rabbits indicates that the differences in the size of different races may be due to something other than differences in chromosome functions.

Ordinary hybridization experiments are greatly limited in what they can be made to reveal as to the relative importance of the chromosomes and other cell organs in the ontogenetic process, since fertile hybrids can be secured only from closely related forms. It is possible, and even probable, that if we could secure fertile hybrids at will between any two organisms, no matter how different, we might find a great many characteristics that would not follow Mendelian laws. In fact, we should not expect Mendelian phenomena except in cases of differences between homologous chromosomes that unite and separate in the usual fashion in the reduction division of the first generation

hybrid. It is probable that the non-appearance of ordinary Mendelian phenomena in very wide crosses may be due to the fact that in such crosses the chromosomes are not strictly homologous, and do not go through the process of synapsis and reduction in a normal manner. But in such crosses, if part of the chromosomes are capable of pairing and separating in the usual way, then we should expect some Mendelian phenomena, such as we actually find in some such crosses.

The theory here proposed is essentially epigenetic. It does not assume that the germ plasm of the fertilized egg contains structural elements each of which is the basis of a separately heritable character, but rather that the organs of the initial cell possess properties that in a measure predetermine the course of development. The influences which determine development are of two distinct kinds. Those of one class result from the chemical, physical, and physiological properties and relations of the cell organs themselves, by virtue of which these organs respond in a given manner to a particular environment. Influences of the other class are found in the environment itself. The environment of a given cell organ consists not only of conditions external to the organism, but of internal conditions as well. The character and amount of food supplied, the presence of substances resulting from the metabolic activities of other cell organs, and even of other and distant parts of the organism, must all be a part of the environment of every cell organ in the body. This environment changes with every step in the ontogenetic process. The conditions surrounding the cell organs in the two-celled stage differ from those in the one-celled stage. In order that a given property of a cell organ may have a determining influence on the final stages of development it is only necessary that it shall properly influence the first step of this development. Then the result of this first step becomes a determining influence on the next step, and so on.

Every tissue, every organ of the body, must be considered as a part of the environment of every other part. As development proceeds, therefore, new determining influences arise. These secondary influences arising at any stage of development, and resulting from the course taken in the earlier stages of development, may be called secondary teleones. They influence further development, and thus come within the definition of a teleone, but they were not in existence in the beginning of development. Likewise, the tissues, organs, and so forth which exert such influences should be considered as secondary teleo-

morphs. To illustrate, let us consider the deposition of pigment in the hairs and skin of the mammalia. That this pigment should finally be deposited, under appropriate conditions, was doubtless predetermined in the germ cell, by what we may call primary teleones; that is, by properties of the organs and substances composing the germ cells. But the deposition of the pigment must wait until the development of a special organ, the skin, has reached an appropriate stage, before the necessary conditions for the production of pigment exist. Thus the skin may be considered as a secondary teleomorph for the normal production of this pigment.

The behavior of those hereditary characters which obey Mendel's law of segregation and recombination may be considered to be due to those primary teleones which are the properties of the chromosomes, or other cell organs which behave in the manner in which chromosomes are known to behave, and which have a determining influence in some necessary step in the development of a given part or function of an organ or of the organism.

To admit the purity of gametes in the Mendelian sense (not in the deVriesian sense) is therefore not admitting that all the hereditary traits of an organism are represented in the germ plasm by specific bodies, but it means merely the admission that certain definite cell organs, the chromosomes, possess properties that give each, or at least a number of them, a determining influence in the development of certain characters. To admit such influence does not mean that a single chromosome is wholly responsible for the development of any organ or region of the body. It merely means that, under appropriate environment, and at an appropriate stage of the developmental process, the chromosome in question, by virtue of some property it possesses, shall affect the further course of development.

We thus see that Mendelian phenomena are consistent with an epigenetic view of development, the course of this development, however, being in a measure predetermined by properties residing in the organs and substances found in the fertilized egg.

REPORT OF COMMITTEE ON EUGENICS.

C. B. DAVENPORT, *Secretary.*

The various duties of the Committee on Eugenics may be summed up in the three words: investigation, education, legislation.

The first, and for some time the main, work of the committee must be *investigation.* We want, above all, to learn as soon as possible how human characteristics are inherited. The results of the new science of heredity give reason for anticipating that many, if not most, characteristics are of an alternative sort, either not reappearing in the offspring or reappearing in predictable proportions, depending upon the distribution of these characteristics in the ancestry. We have already seen that a score or more of characteristics, largely specific diseases, are inherited in such alternative fashion, and about their behavior in progeny definite information has been given. We must ascertain the facts about other characteristics.

The data must first be collected; then analysed. This work is so vast that it must be divided between many people--specialists able to weigh and analyse scientifically the results. Consequently it has been found desirable to appoint sub-committees to collect and study the data. A sub-committee on Feeble-mindedness has been organized under the chairmanship of Dr. A. C. Rogers, Superintendent of the Minnesota School for Feeble Minded and Colony for Epileptics, and with Dr. H. H. Goddard, Director of the Department of Psychological Research at the New Jersey Training School for Feeble Minded Girls and Boys, as secretary. At the present moment this committee is collecting answers to the question: "Do two imbecile parents ever beget normal children?" This committee has most important interests, since the number of feeble-minded in the United States alone is probably not less than 150,000, of which 15,000 are in institutions.[a]

A sub-committee on Insanity is being organized under the chairmanship of Dr. Adolf Meyer, for some time Director of the Pathological Institute of the New York State Commission in Lunacy and recently appointed head of the Phipps Psychiatrical Institute at the Johns Hopkins University. The secretary of this sub-committee is Dr. E. E. Southard, Pathologist to the State Board of Insanity, Massachusetts. This sub-committee has important work to do, for there are over 150,000 insane in the institutions of the United States alone.

[a] Bureau of Census. Special Reports: Insane and Feeble-minded in Hospitals and Institutions. 1904, p. 205.

Other sub-committees are contemplated to study the protoplasmic basis of eye defects, deafness, predisposition toward lung and throat trouble, toward diseases of the excretory and circulatory organs; toward cancer, skin diseases, crippled appendages and so on. Still other sub-committees should deal with criminality and pauperism, with the effects of consanguineous marriages and of such mongrelization as is proceeding on a vast scale in this country. Perhaps other sub-committees, recruited from those who make physical examinations, will study inheritance of muscular strength, of sound wind and endurance. Possibly registrars of colleges will serve on sub-committees for the study of inheritance of various intellectual traits. Other sub-committees will be added as needed.

A second class of investigation may better be undertaken by the central committee. It is the obtaining of records of the inheritance of characteristics of health, ability and temperament from typical American families. In the attempt to secure such records 5,000 blanks have been distributed and about 300 family records received back. These are being studied to determine the laws of incidence of disease and the inheritance of various other characteristics. This sort of work might be taken up by genealogists who wish to incorporate more biological data in their family histories. The limitations to this work are set only by lack of means for carrying on correspondence. It seems possible that data of this sort might be collected by the national Bureau of the Census for limited registration areas.

While the acquisition of new data is desirable, much can be done by studying the extant records of institutions. The amount of such data is enormous. They lie hidden in records of our numerous charity organizations, our 42 institutions for the feeble-minded, our 115 schools and homes for the deaf and blind, our 350 hospitals for the insane, our 1,200 refuge homes, our 1,300 prisons, our 1,500 hospitals and our 2,500 almshouses. Our great insurance companies and our college gymnasiums have tens of thousands of records of the characters of human blood lines. These records should be studied, their hereditary data sifted out and properly recorded on cards and the cards sent to a central bureau for study in order that data should be placed in their proper relations in the great strains of human protoplasm that are coursing through the country. Thus could be learned not only the method of heredity of human characteristics but we shall identify those lines which supply our families of great men: our Adamses, our

Abbotts, our Beechers, our Blairs, and so on through the alphabet. We shall also learn whence come our 300,000 insane and feeble-minded, our 160,000 blind or deaf, the 2,000,000 that are annually cared for by our hospitals and homes, our 80,000 prisoners and the thousands of criminals that are not in prison, and our 100,000 paupers in almshouses and out.

This 3 or 4 per cent of our population is a fearful drag on our civilization. Shall we as an intelligent people, proud of our control of nature in other respects, do nothing but vote more taxes or be satisfied with the great gifts and bequests that philanthropists have made for the support of the delinquent, defective and dependent classes? Shall we not rather take the steps that scientific study dictates as necessary to dry up the springs that feed the torrent of defective and degenerate protoplasm?

Greater tasks than those contemplated in the broadest scheme of the Eugenics Committee have been carried out in this country. If only one-half of 1 per cent of the $30,000,000 annually spent on hospitals, $20,000,000 on insane asylums, $20,000,000 for almshouses, $13,000,000 on prisons, and $5,000,000 on the feeble-minded, deaf and blind were spent on the study of the bad germ-plasm that makes necessary the annual expenditure of nearly $100,000,000 in the care of its produce we might hope to learn just how it is being reproduced and the best way to diminish its further spread. A *new* plague that rendered 4 per cent of our population, chiefly at the most productive age, not only incompetent but a burden costing $100,000,000 yearly to support would instantly attract universal attention, and millions would be forthcoming for its study as they have been for the study of cancer. But we have become so used to crime, disease and degeneracy that we take them as necessary evils. That they were, in the world's ignorance, is granted. That they must remain so, is denied.

The second great duty of the Committee on Eugenics, education, is not less important than investigation. For the ascertained laws would be more than scientifically interesting; they would be guides to action on the part of the reading, thinking public. As precise knowledge is acquired it must be set forth in popular magazine articles, in public lectures, in addresses to workers in social fields, in circular letters to physicians, teachers, the clergy and legislators. The nature and the dangers of unfit matings, the way to secure sound progeny, must ever be set forth.

And, finally, when public spirit is aroused, its will must be crystallized in appropriate legislation. Since the weak and the criminal will not be guided in their matings by patriotism or family pride, more powerful influence or restraints must be exerted as the case requires. And as for the idiots, low imbeciles, incurable and dangerous criminals, they may under appropriate restrictions be prevented from procreation —either by segregation during the reproductive period or even by sterilization. Society must protect itself; as it claims the right to deprive the murderer of his life so also it may annihilate the hideous serpent of hopelessly vicious protoplasm. Here is where appropriate legislation will aid in eugenics and in creating a healthier, saner society in the future.

We come now to the practical question, How can the necessary studies be made? It is believed that the Committee on Eugenics may well be entrusted with organizing the work along the lines that have been successfully begun or it would cooperate with anybody that seemed better able to organize the work. But it can do nothing without funds. The committee does not solicit funds—but it stands ready to do the nation's business by making clear the nation's need to legislators and to philanthropists. One can not fail to wonder that, where tens of millions have been given to bolster up the weak and alleviate the suffering of the sick, no important means have been provided to enable us to learn how the stream of weak and susceptible protoplasm may be checked. Vastly more effective than ten million dollars to "charity" would be ten million dollars to eugenics. He who, by such a gift, should redeem mankind from vice, imbecility and suffering would be the world's wisest philanthropist.

INHERITANCE OF HATCHING QUALITY OF EGGS IN POULTRY.

RAYMOND PEARL, *Orono, Maine.*

1. There has recently been completed a general study of the influence of certain factors on the fertility and hatching quality of hen's eggs.[a] Amongst other factors, inheritance received particular

[a] Cf. Pearl, R., and Surface, F. M. Data on Certain Factors Influencing the Fertility and Hatching of Eggs. Maine Agr. Expt. Station, Bulletin 168, pp. 105-164. 1909.

attention in this study. Certain of the results obtained in regard to this factor suggest conclusions believed to be of some general significance in relation to the practical breeding of other animals than poultry. On this account I venture to present here a brief summary of these results and to point out the considerations suggested by them which seem to me likely to be of interest to animal breeders in general.

2. The actual results obtained regarding the inheritance of the developmental qualities of eggs may be first set forth. For a detailed account of these results the original paper must be consulted. By way of definition it should be said that in this study "fertility of eggs" was measured as per cent of eggs set which were infertile; and "hatching quality of eggs" was measured by the percentage of fertile eggs which hatched. Correlation tables were prepared showing (a) the mother's and the daughter's percentage in fertility of eggs, and (b) the mother's and daughter's percentage of fertile eggs hatched, for every mother-daughter pair for which complete records extending through a whole hatching season (March 1 to June 1, *circa*) were available. The numerical results obtained from an analysis of the correlation table relating to hatching quality of eggs are shown in the following table:

Hatching quality of eggs in mothers and daughters.

Constant	Hatching quality of eggs
Number of mother-daughter pairs	87
Mothers' mean percentage of fertile eggs hatched	52.96 ± 1.23
Mothers' standard deviation	17.00 ± .87
Mothers' coefficient of variation	32.00 ± 1.80
Daughters' mean percentage of fertile eggs hatched	47.67 ± 1.80
Daughters' standard deviation	24.92 ± 1.27
Daughters' cofficient of variation	52.27 ± 3.32
Coefficient of correlation between mother and daughter	.031 ± .072

There are a number of interesting matters brought out by this table, but we will here confine our attention to the main point, which is that there is no sensible correlation between mother and daughter in respect to hatching quality of eggs. Even though we make the appropriate corrections to allow for the selection of the mothers, it still remains the case that the correlation is insignificant. It is not, however, justifiable to conclude that there is no inheritance

of this character—"hatching quality of eggs"—because of the absence of a sensible correlation between mother and daughter in regard to it. The character may be inherited, but in a manner which is not well brought out by the ordinary parent-offspring correlation table.

3. Another line of approach shows that, as a matter of fact, this character is inherited, and in a definite and sensible degree. A correlation table was formed which showed for every possible pair of full sisters which occurred in the pedigree records the percentage of each sister's fertile eggs hatched. The coefficient of correlation indicating the degree of "fraternal" inheritance with reference to this character was calculated with the following result:

Correlation between sisters in respect to per cent of fertile eggs hatched, $r = 0.188 \pm 0.060$.

Or, in other words, we get here a sensible positive sister-sister correlation. There is a definite degree of what may be called "fraternal" or collateral inheritance of the character "hatching quality of eggs," even though this character is *apparently* not inherited in the ancestral line.

The apparent contradiction in the results from parental and fraternal correlation here is only apparent and not real. We may expect to get sensible coefficients of fraternal inheritance associated with low or insignificant parental coefficients, whenever the phenomenon of *prepotency* in the ancestral line occurs. This is exactly what careful study of the individual records shows to exist in the present material. The point is that the absence of a significant parental correlation does not mean that hatching quality is not inherited. It merely means that the existence of such parental inheritance is masked by the existence of varying degrees of prepotency with reference to this character amongst the mothers. The existence of such prepotency is perfectly apparent from the study of individual pedigree records and from the correlation between sisters in regard to this character. This case well illustrates the danger which may lie in too hastily drawing conclusions from *mass* material without careful study of the individual cases.

The general result which is reached from this study is that the character "hatching quality of eggs" (measured by per cent of fertile eggs hatched) is definitely inherited in the female line and probably also in the male line.

4. If hatching quality of eggs is an inherited character it is clearly something which can be improved by proper selective breeding. In the poultry breeding experiments at the Maine station selection with reference to this character is being practiced. This is done practically through the use of what has been called a selection index number.[b] The selection index number in actual use for poultry has the formula:

$$I_1 = \frac{5(a+b)}{c+d+1}$$

wherein I_1 denotes the selection index number;

a = percentage of an individual bird's fertile eggs hatched;

b = percentage of eggs actually laid by this bird to the total number it was possible for her to lay between February 1 and June 1 (*i. e.*, the breeding season) of the year for which the index is calculated;

c = percentage of this bird's eggs infertile;

d = percentage of total number of this bird's chicks which die within three weeks from the date of hatching.

It is clear that in this index the hatching quality of eggs is relatively heavily weighted. Results already obtained appear to show a beneficial effect of this selection, and indicate the probability of a more marked effect in future generations.

5. In all practical animal breeding one of the most important factors in the determination of relative success or failure is what may be called the "breeding capacity" of the stock. By "breeding capacity" in this sense is meant, broadly speaking, the ability of the stock to produce vigorous healthy young in relatively large numbers.

In the selective breeding of nearly all of our domestic animals, whether for fancy or utility points or both, little or no attention has been paid to the breeding capacity of the stock. Like the poor in human society, the "shy breeder" among thoroughbred animals is always with us. The experimental investigation here summarized shows definitely, however, that in poultry the chief factor concerned in "breeding capacity," namely, hatching quality of eggs, is inherited. It is highly probable that "breeding capacity" depends upon essentially and fundamentally the same biological factors in all of the domestic animals. There would appear to be three fundamental factors primarily concerned in the determination of whether a fertilized

[b] Pearl, R., and Surface, F. M. Selection Index Numbers and their Use in Breeding. Amer. Nat., Vol. XLIII, pp. 385-400. 1909.

ovum shall develop into a healthy and vigorous organism: (a) A normal *structure* of the developmental machine (ovum, embryo, etc.); (b) an adequate endowment of *energy* with which to carry through the developmental processes until the stage in development is reached where energy may be obtained from external sources; and (c) a normal degree of *resistance*—probably originating through the existence of (a) and (b)—to the ordinary environmental vicissitudes which every individual must meet in the course of its embryonic life. I can see no reason why these factors should not operate in an essentially similar manner in cattle, sheep, and swine, for example, as well as in poultry. But if this is the case, and at the same time, as we have shown, the general effect of the operation of these factors is definitely inherited in poultry, it strongly suggests the possibility that by paying attention to "breeding capacity" and selecting with reference to it in all breeding operations, whatever their primary objects, it may be possible to improve considerably this character in thoroughbred live stock in general.

[Presented by Committee on Breeding Poultry.]

INSECT BREEDING.

VERNON L. KELLOGG.

There are so few domesticated insects—the honey-bee and silkworm are the only conspicuous ones—that insect breeding is a field little worked. In recent years the experimental breeding of a few undomesticated kinds, notably various species of beetles in the hands of Tower at Chicago, Johnson at the Carnegie Laboratory of Experimental Evolution at Cold Spring Harbor and McCracken at Stanford, has been carried on by students interested in problems of heredity. The results of this breeding are of value primarily to pure science, but secondarily to practical science. Any specific definite knowledge of the order or laws of inheritance in insects is bound to be sometime useful knowledge.

For example of how such knowledge sought and gained by students of heredity without any particular thought of a practical application of it may nevertheless have an immediate economic importance, I may refer to a case of partly personal work.

For the last eight or nine years I have bred experimentally each year many thousands of individuals, representing pure cultures and crosses of fourteen races of silkworms, in an attempt to discover whether this insect followed Mendelian principles in its inheritance, or, if not, what other order of heredity was discoverable. Incidental to the main object of the work opportunity was afforded by this extensive and protracted series of rearings to test various other particular problems correlated with inheritance.

Practically all the generalizations that economic silkworm breeders may utter concerning the effects of crossing, based on their centuries of continued but desultory and unplanned breeding, can be printed on a single page of this size. Indeed, in the latest authoritative French manual of silkworm culture a direct attempt to sum up the knowledge of inheritance in silkworms does occupy just about that much space. Now if the results of the recent few years' work of scientific breeding by Contagne in France, Toyama in Japan and myself in this country be generalized, the statements of fact touching the course of inheritance in silkworms are much more extensive and definite than all those empirically gained during hundreds of years previous. Not that their application to practical silkworm breeding can produce conditions as much better compared with present ones as present ones are better than the first one, because no such further great biological betterment is possible. But if a silkworm breeder were to start today again from the primitive conditions without the knowledge gained by centuries of breeding, but only with that gained by the last ten years of scientific experimental work, he could reach the same breeding conditions that now exist in immeasurably less time than it has actually taken. The order of inheritance of larval and pupal (cocoon) characters of silkworms is now fairly definitely known. Hybridizations made in the light of this knowledge can accomplish with great certainty and swiftness results that would otherwise require untold time and much "trial and error" following uncertain paths.

Just as the rules of inheritance in silkworms have been worked out so they can be for the honey-bee. And this knowledge is much needed. Real and great improvement in beekeeping can be made on a basis of such knowledge; more indeed than can now be made in silk-raising.

Also there will come soon—it must have come already—a demand from the economic entomologists who are collecting and disseminating insect parasites of insect pests for a more accurate and detailed knowledge of their behavior when bred under conditions different from their usual ones. This knowledge can only be got from extensive series of experimental rearings. Whether parasites of hosts not identical with but closely allied to American pests can be "induced" by selective rearing to change their food habits a little to our advantage, or whether under new conditions parasites of promise may not tend to scatter their efforts and become less useful: these are examples of queries that must already be coming to the student of parasites and must be answered by him on a basis of planned experimental rearing. And from experimental rearing to selecting and hybridizing, that is, to "breeding," is but a step. We shall have more domesticated insect species soon if by domestication is meant amelioration or modification by breeding.

[Presented by the Committee on Breeding Bees and Other Insects, DR. L. O. HOWARD, Chairman.

HYBRIDIZING GAME BIRDS IN CAPTIVITY.

WALLACE EVANS, *Oak Park, Illinois.*

Hybridism among our native game birds in a wild state is in general not very common, but in the pheasant family it is quite prevalent, especially so among those raised in captivity. Some breeders take great delight in the crossing of these beautiful creatures.

I am sorry to say it has been a great drawback to the breeders who are striving year after year to keep their flocks pure. To illustrate the mischief done along these lines, I would refer to the Amherst and Golden Pheasants as furnishing a striking example, it being almost impossible to purchase birds of one of these varieties, either in this country or Europe, that are not tainted with the blood of the other. It is not my intention to claim in this paper that hybridism among game birds is beneficial except in a few well-selected varieties, and even then there are doubts. I can only speak of my own experience up to the present. As time passes, however, it may become apparent that what I now consider an improvement is only temporary, and the hybrids that now appear to me as an improvement may as years go

by prove otherwise. I must admit that as far as the pheasant family is concerned hybridism is detrimental, with possibly a few exceptions, and even with these few there are grave doubts as to its being beneficial in the long run.

As an illustration I will mention the crossing of the English Ring-Neck Pheasant *(Phasianus torquatus)* with the Dark-Necked Pheasant *(Phasianus colchicus)*. The offspring of these two parents at first, or for the first year or so, appears to be an improvement in size, contour, and color, excepting, of course, that the white rings around the neck diminish in size. In a few years, however, it becomes very apparent that the improvement, if at all, is only temporary, for the birds now begin to show a faded or what breeders call a "washed-out" appearance. They lose their beautiful sheens or iridescent colorings and do not at all compare in beauty with the pure-bred parent stock.

The crossing of the Golden Pheasant with the Amherst Pheasant furnishes one of the most conspicuous examples of the detrimental effects of hybridism. Like *colchicus* and *torquatus*, their eggs are fertile and hatch fairly well. The male bird from the first cross when in its full nuptial plumage appears very beautiful indeed to the inexperienced breeder, but to the true fancier and breeder this gorgeous mongrel has neither charm nor place.

If hybrids of these varieties are allowed to breed among themselves year after year their colorings become mingled to such an extent as to make them displeasing to the eye of even a casual observer. They also diminish in size and lose the nice shape of the pure-bred bird. Eventually they breed out entirely unless new blood is frequently introduced. Therefore, I claim that there is nothing to be gained by hybridizing these two varieties.

A great many breeders of pheasants, especially amateurs, wail and wonder why they cannot raise successfully the young of the Golden and Amherst, also other varieties. During the breeding season I receive numerous letters from parties all over the country asking for advice and stating that they have failed to raise the young birds. Most of them in telling their troubles simply state that the young birds seem to wilt and die off without any apparent cause during the early stages of their existence. While I will admit that there are many other causes that may have had something to do with these failures, yet to those who have failed I will say that, strange and perplexing though it may seem to them, one of the chief reasons is

hybridism—the bird that laid the eggs or its mate is a hybrid, a mongrel, and the chances are that neither you, I, nor anyone else could have raised the young to maturity. Nature here has stepped in to prevent their increase; it is simply one of the many cases where man has failed to improve upon nature's handiwork, and in her wisdom she has interfered to prevent the increase of that which is not an improvement and which would soon result in the loss of the original.

Pheasants of the same genus are generally fairly prolific when crossed but the eggs of a bird mated up with one of a different genus are seldom fertile, and in the few cases where they are fertile the offspring is not capable of breeding again; there is, therefore, nothing to be gained by trying to cross birds of a different genus.

During the past breeding season I got very good results by crossing the pure-bred Mongolian Pheasant *(Phasianus mongolicus)* with *P. torquatus,* using the Mongolian male and the *torquatus* female. These two being of the same genus proved to be very prolific and the offspring seemed to be quite strong; the colorings, rich and deep; flight, high and swift. This being my first season in crossing these two varieties, I cannot say how they will turn out on the second cross; but from all appearances I think they will prove a fine game bird for this country.

Another very interesting hybrid is the offspring of the Reeves Pheasant crossed with the English Pheasant.

Waterfowl hybrids are also very interesting. One of the most singular cases of the crossing of wild geese I have accomplished was by mating a Canada gander with a female Tiger Brant (White-fronted Goose). The offspring of this union are very peculiar in appearance, having light smoky cheeks, tiger markings on the breast, and the white front at the base of the beak similar to that of the mother bird. In size they are slightly smaller than the Canada goose, but their shape and carriage is more pleasing to the eye of the observer than that of either parent.

[Presented by Committee on Breeding Wild Birds.]

EDITORIALS

The Field of the Breeder.

The decision of the Council of the American Breeders Association to publish a quarterly magazine, in addition to its Annual Report, will be hailed with pleasure by a great number of investigators and practical breeders. The art of animal and plant breeding, though rapidly advancing, is still in its infancy. It is only within the last twenty years that the laws of heredity, on which all successful work in this line depends, have become at all susceptible of comprehension or of definition. This art, like all others, cannot be long practiced as a trade by rule of thumb. It must rest on science, and science must be exact, so far as it goes, else it is not science at all.

The science on which the art of selective breeding rests consists in the main of five categories of knowledge: Variation, heredity, environment, selection, and segregation. We have, first, variation, its facts and its factors. No two animals, no two plants, no two seeds, no two germ cells in this world were ever quite alike. On this rests the possibility of change in the succession of life, and with change the possibility of improvement. And by improvement the practical breeder means fitness for the use of man. In nature, improvement means greater fitness for the struggle of life, greater power of holding its own. This natural improvement is something very different from that which man seeks, and most creations of the breeder would fare badly in the rough and tumble of the desert or the woods. Both ideals are again different from that of structural advancement. It is now and then an advantage in the struggle for existence for animal or man to have structural complexity. But it is not always so. The world swarms today with one-celled animals and plants, more numerous and more varied than in the dawn of life. The development of man through sheer ingenuity rather than strength is an exception in nature, and of man there are plenty of individuals, but not many species.

With variation goes the fact of heredity. Like produces almost like, and this difference in likeness is largely due to the fact that in all the specialized groups of animals and plants each individual has

two parents. Each individual shows a mosaic of characters drawn from each parent, and through each from farther ancestors; and besides the characters shown or "dominant" there are other characters hidden or "recessive," which may be as patent in lives of future generations as the traits which are dominant. Each individual has twice as many ancestors as his father or mother had, hence no individual can be an exact or slavish copy of either parent. The physical basis of heredity is in part understood. Its laws or methods of operation are becoming each day more clearly understood, and the persistence of type from generation to generation is the solid ground on which the selective breeder rears the structure of his specific creations.

The fact that in every way the laws of heredity and the related laws of life are absolutely the same in man and the animal kingdom gives the studies of animal breeding the greatest practical value as applied to man. The evil effect of the destruction of the best, and of breeding from the weak or inert, is just as plain in the history of Greece and Rome as it can be in the history of a neglected or abused herd of cattle.

With these studies goes the investigation of the effects of the environment on the individual and on the race. With the increase of knowledge we have seen that the environment is an indirect factor in race changes. It does not influence the race by its effect on the individual, but rather by its power to determine what sort of an individual shall survive. There is still much to learn of the way in which environment influences the process of variation, and the whole subject affords material for the most clever experimentation.

Of course, all artificial race improvement must rest on artificial selection, as all natural advance is conditioned on natural selection. The art of crossing to promote variation, with choice of resultants, constitutes the fine art of selective breeding. Selection without segregation or separation is ineffective, whether natural or artificial. The results of segregation rise in greater and greater importance, with closer study of their character and meaning.

All these subjects as related to the breeding of animals and plants, and men, for men are higher animals, will find treatment in this new magazine. We are sure that such a repository of available truth on the vital questions will find a deserved welcome.—DAVID STARR JORDAN.

Breeding: A Great Economic Movement.

Through the agency of plant and animal forms the United States annually produces wealth to the amount of eight billion dollars. Of this, at least five billion is produced by cultivated plants and domesticated animals, in which the forces of heredity are, in a large measure, coming under the will of man. Authenticated records exist of instances in which the value of the product has been increased 10, 25, and even 50 per cent by systematic breeding. Practically all those who have had successful experience in creative breeding agree that it is conservative to estimate that by this means an average of 10 per cent can be added to the value of this five billion dollars worth of products.

The American Breeders Association has assumed to lead in the organization of cooperation among private and public agencies to bring about annually the addition of this $500,000,000 of wealth. A number of States are organizing plant breeding establishments. The United States Department of Agriculture is cooperating with the State experiment stations in this work; and both have much independent creative breeding work with many species of plants and breeds of domestic animals. The State experiment stations, the United States Department of Agriculture, and other research organizations, as the Carnegie Institution, Harvard University, Cornell University, and Leland Stanford University, are studying the laws of heredity.

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Give the Magazine to a Friend.

The American Breeders Association selects for publication in the *American Breeders Magazine,* from the papers given at the annual meetings, and reprints most of them in the bound Annual Report. For the latter are reserved other articles, but especially those rather too ultra-scientific for the *Magazine.* Thus the scientific articles appear in the bound volumes. The five Annual Reports already published show what a rich library on heredity and breeding may be built up by every member of the Association.

The plan of giving the *Magazine* when read to a friend enables the members to use their copies of the *Magazine* to help them in securing new members. Therefore when you have read a number hand it or mail it to someone who ought to be a member of the

American Breeders Association. Speak to him or write him a letter inviting him to become a member. If you think it would help write the Secretary of the Association requesting him to join you in inviting your friend to become a member. Try thus to make your four quarterly numbers help you get one or more new members.

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Making of Hybrids Not Understood.

People generally have a wrong conception of the process of creating new hybrids between varieties, breeds, or species. The hybrid is not a general compounding of the two parental forms. Often the average of a large number of hybrid individuals of the first, second, or later generation is not an improvement over the original. Sometimes the first generation hybrid is an improvement because a group of valuable characters are dominant in this generation. This dominance may not mean, however, that the average of the second and later unselected generations is superior to either parent. The mass of individuals—progeny of a union of two given species—cannot be called a hybrid variety or breed. Any such mass is made up of many varying elements; often it is apparently a tangle of unit characters. A pure-bred variety or breed can be produced only by most rigid selection from large numbers of the hybrid, both to secure excellence and to secure at least reasonable uniformity. In other words, the breeder produces many hybrid individuals and discards all but possibly one in thousands. This closely selected hybrid stock then represents not the average between the parents but the recombination of certain desired characters of both parents. The original act of hybridizing is usually a very simple matter. The scientific method, the artistic skill, and the long-continued, careful, patient effort from the second generation on are the larger factors. Intelligence almost akin to genius is required in hybridizing, to extract from the hybrid those blood lines which will make the most valuable recombination of the characters possessed by the two parents.

Animal Hybrids.

The experiment in hybridizing Brahma and European cattle, as described on page 91 by Mr. Borden, and the brief statement by Mr. Riley on page 107 introduce the subject of the wider introduction and hybridizing of domestic and wild animals. Wide cooperation between institutions interested in improving our domestic animals and the keepers of zoological parks has been

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People generally have a wrong conception of the process of creating new hybrids between varieties, breeds, or species. The hybrid is not a general compounding of the two parental forms. Often the average of a large number of hybrid individuals of the first, second, or later generation is not an improvement over the original. Sometimes the first generation hybrid is an improvement because a group of valuable characters are dominant in this generation. This dominance may not mean, however, that the average of the second and later unselected generations is superior to either parent. The mass of individuals—progeny of a union of two given species—cannot be called a hybrid variety or breed. Any such mass is made up of many varying elements; often it is apparently a tangle of unit characters. A pure-bred variety or breed can be produced only by most rigid selection from large numbers of the hybrid, both to secure excellence and to secure at least reasonable uniformity. In other words, the breeder produces many hybrid individuals and discards all but possibly one in thousands. This closely selected hybrid stock then represents not the average between the parents but the recombination of certain desired characters of both parents. The original act of hybridizing is usually a very simple matter. The scientific method, the artistic skill, and the long-continued, careful, patient effort from the second generation on are the larger factors. Intelligence almost akin to genius is required in hybridizing, to extract from the hybrid those blood lines which will make the most valuable recombination of the characters possessed by the two parents.

Animal Hybrids.

The experiment in hybridizing Brahma and European cattle, as described on page 91 by Mr. Borden, and the brief statement by Mr. Riley on page 107 introduce the subject of the wider introduction and hybridizing of domestic and wild animals. Wide cooperation between institutions interested in improving our domestic animals and the keepers of zoological parks has been

suggested in order that more may be known of the kinds of hybridizing which may be done among species and among domesticated breeds and wild species. The editor invites a general discussion of this subject.

Brahma Cattle Hybrids.

In connection with the importation of Brahma cattle, numerous questions arise: Would pure-bred Brahma cattle pay better in our southern section from Texas to Florida than the cattle of Europe? Would it not be wise to introduce both the best milking breeds and the best meat breeds from India? Mr. Fairchild reports that there are good milking breeds in India. Would it not be well to import them and to produce for our Southern States a cross between our highly developed dairy breeds and these Brahma dairy breeds? May it not be possible to produce hybrid beef breeds with considerable dairy ability? Might not an infusion of the blood of the best European and American beef cattle form a better basis for economic meat production in India than the present breeds of Brahma cattle? Could not India greatly improve her dairy breeds by widely hybridizing the best native dairy breeds with the best pure-bred dairy blood of Europe and America? Mr. Fairchild's reference to the beef and milk breeds of Brahma cattle in Bulletin No. 27 of the Bureau of Plant Industry, 1902, seems to have opened up a most interesting question.

Horse Hybrids.

It would seem that there exist in the various races of horses, donkeys, and zebras characters which if recombined to the best advantage might produce hybrid work animals much superior to the forms we now possess. The fact that the horse-donkey hybrid is sterile need not be taken as an unsurmountable obstacle. There may be found ways of so crossing three or more species that fertile hybrids may be produced which include the blood of the horse, the donkey, and the wiry zebra. And it may be possible to segregate from many such hybrids a few rare individuals with the power to become a mighty race of horse hybrids. There are certainly qualities in these species which if the recombination could be made and segregated would make most valuable animals. Those in charge of investigations with horse hybrids are anxious to trace up any cases of alleged fertile horse-donkey hybrids.

The Section Organization.

Under the terms of the vote changing the Constitution, the chairman of the Committee on Eugenics, President David Starr Jordan of Leland Stanford University, and the secretary, Dr. C. B. Davenport of the Station for Experimental Evolution of the Carnegie Institution, become respectively the chairman and secretary of the new section. It is understood that the sub-committees of the Committee on Eugenics will now be called committees of the Association. It is hoped that by the next issue the committee organization can be given. Dr. C. B. Davenport by virtue of his office as secretary of the Eugenics Section becomes one of the editors of the *Magazine* and of the Annual Report.

¶ ¶ ¶

The Movement to Study Eugenics.

Those who led in organizing the study of heredity in man as a branch of the work of the American Breeders Association saw something of the difficulties as well as of the possibilities for good in this line of effort. It was firmly believed that the membership and the scientific leadership in this virile new organization furnished the best available auspices under which work in eugenics could be begun. Here are associated those who will conserve the formal traditions and will seek for truths upon which still better traditions may be built. The group of workers chosen by the membership of this Association to work at this problem will be sane, safe and conservative. It is believed that such a group of chosen leaders will gain an authoritative place in the discussion of the subject which will reduce to a minimum the irrational discussion of the subject by those merely seeking notoriety or by those who might carelessly weaken the morality which is growing up with family life.

¶ ¶ ¶

Narrow Limits for Breeding Men.

None know so well as the breeders of plants and the breeders of animals the narrow limitations prescribing the selective breeding of the races of men. On the other hand, the paramount importance of the species makes even small improvements relatively of large value. While restrictions upon people with abnormal heredity may be a result of scientific investigation, doubtless much the larger work is the develop-

ment of a body of sane knowledge and its dissemination for voluntary use. The religious impulse of the human family to do that which is good for the whole people and is beneficial to posterity will no doubt serve in putting into operation such suggestions as the science of eugenics may find it important to make. In no other line can science and religion so closely cooperate as in the production of races of strong people. None should feel a more vital interest in research in eugenics than those who have been chosen to direct the moral and religious life of the community.

The extensive moral and educational movements on which eugenics must chiefly depend to carry forward its teachings will come whenever the time is ripe. But this may be added, that social workers are learning how to start, organize and carry on nation-wide and world-wide moral movements. The world is learning how to marshall its spiritual and intellectual and moral forces. That these movements do at times proceed grievously slow should not be held against them, but is rather in their favor. It would be effort well spent if as a result of an educational eugenics campaign this country could show at the close of the century a reduction or at least a check in the expenditure of $100,000,000 annually now being made for the maintenance of hospitals for the insane, asylums for the feeble-minded, prisons, reformatories, and similar institutions.

A greater total of human happiness, higher social standards, higher average of individual efficiency, greater personal security would be the gain, if within this century it became possible to reduce the present three and a quarter million defectives, criminals, insane, vicious and incapables in various institutions in the United States by ever so small a fraction, purging the blood current of the nation of base heredity elements and producing less of the human wreckage which fills those institutions. Once the energies of man are directed to the study of heredity in his own race it may be that both the average of heredity values and the number of geniuses may be increased. In any event good and not harm is assured from the movement modestly but powerfully inaugurated.

Who knows but that students will make discoveries of stupendous moment in eugenics? This word is yet so new as the chosen symbol to name the theme of the study of heredity in man, that relatively few have even seen or heard it. Yet ere a generation has passed, it may be that the leading characters of all the members of each family

in the entire country will be card-indexed. When will there be courses of study to prepare men and women to collect, tabulate, and interpret the statistical facts of how heredity manifests itself in all families and races and in all the many mixtures of the blood of peoples which have come from all climes and represent all tongues? The fact that the Committee on Eugenics of the American Breeders Association appreciates and insists that eugenics must be investigated before it can be taught, is an assurance that this work will proceed cautiously and with due regard for all family and general social traditions. It is not unlikely that portions of these teachings can best be promulgated through the church and through other educational agencies less public than the common schools. But that the fires of science will light up many places now dark in the betterment of plant, animal and human forces is a foregone conclusion. The American Breeders Association has made no mistake in assuming to guide the thought along these lines as well as to promote great activity in their consideration.

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An Office for Eugenics Records.

An office for eugenics records has been opened at Cold Spring Harbor, Long Island, New York, by C. B. Davenport, secretary of the Eugenics Section. This office will be under the immediate charge of Professor H. H. Laughlin, superintendent. Through the assistance of a friend of the work, a house has been secured, a small fireproof addition will be built, and the work of installing records already collected and of gathering additional records has begun. Six field visitors, working for the most part in connection with State institutions, will assist in the study of the records. It is hoped that professional men and those successful in various lines of activity will take an interest in affording data for the study of inheritance of their family traits. Blanks for such family records are still available and will be sent out from the above mentioned office.

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NEWS AND NOTES

Heredity in School Children.

The London Times, of Wednesday, April 13, 1910, contains a thoughtful leader under the heading "Eugenics." It is pointed out that the systematic extension of the new science of eugenics is beginning to make itself felt in the investigation of many questions of great significance, concerning which it is important for the national welfare that we should arrive at correct conclusions.

Investigations by Mr. Heron, Galton Research Fellow, in the Galton Laboratory for Eugenics, are referred to in the article. Mr. Heron, from research based upon the London County Committee school survey, embracing twelve schools, formulates as his conclusions from that particular investigation that "There is no sign of an environmental condition producing an effect on the mentality of the child, at all comparable to the known influences of heredity."

Two New Varieties of Winter Rye.

In an article appearing in the initial (January) number of the *Zeitschrift fuer das gesamte Getreidewesen* (Grain Journal, Breslau, Germany), Dr. Kurt v. Ruemker, director of the Agricultural Institute, Breslau, describes the methods by which he originated two new and commercially valuable varieties of rye, and summarizes the results, observation, and experience of eight years' work in the breeding of rye.

Color of the grains of rye is an hereditarily transmissible characteristic, capable of fixation by selection, and therefore of direct practical value. The bluish green color of grain transmits more intensively and regularly than the grass-green or yellowish green shades. A characteristic of the grains of the latter two colors is that the resulting plants are coarse, the grain heavier but softer, and plants inclined to lodge. The green-grained varieties were observed to stool more freely than the yellow grained varieties. Brown-grained varieties lacked hardiness and also were low yielders of both grain and straw. The darker the shade of brown the lower were the yields.

This also applies to varieties with brown-tipped germ ends. There is objection also to short-grained ryes, because shortness of grain is intensified by heredity and is correlated in direct ratio to yield of straw and per cent of grain. No relation could be established between color of grain and shape of spike, and length of the growing and fruiting period. The per cent of grain to straw decreased almost regularly as stooling propensity increased. Where a variety shows inclination to stool abundantly, it is important, in making selections, to give preference to the heaviest yielding stalks.

Protein content has less relation to color of grain than to plumpness, increasing as that increases.

Yellow-grained varieties were more difficult to develop than the green-grained, but once developed transmitted that characteristic with greater regularity and certainty and much sooner reached the point of gametic purity than the green. Rye seems to produce xenias in the same way as corn. Yellow-grained varieties of winter rye seem convertible into spring rye more easily and quickly than the green-grained. Whatever be the color or variety, it has little established agricultural value unless its heredity is known and unless it comes of selected strains.

With open-pollinated species, selection and separation of types in the first generation is not sufficient to fix types, but must be followed by repeated selections. Even with close-pollinated species selection must be continuous.

The Khedivial Agricultural Society of Egypt has voted funds for the establishment of a Mendelian Experiment Station, at Cairo, Egypt, for the study of heredity in cotton. This is probably the first institution devoted to the study and application of Mendelian principles to the improvement of plants for economic purposes.

The Garden Island Honey Company, of Honolulu, H. I., is planning to establish a breeding station for the improvement of Italian bees on an isolated island of the group, as soon as necessary arrangements can be made. The company hopes not only to improve the bees but also to furnish an early supply of queens to bee keepers in the Northern States.—E. F. PHILLIPS.

Cornell Poultry Building.

The legislature of the State of New York recently appropriated $90,000 for a poultry building at Cornell University and a 50-acre tract has been set apart for poultry work on the University Farm. The poultry division of the College of Agriculture of New York has a corps of nine technical people. Prof. J. E. Rice, the head of this division, is to be congratulated.

To most people the hen seems an unimportant part of American agriculture. They do not seem to be aware that our poultry, with a product of nearly $700,000,000 annually, stands beside the dairy, wheat, and cotton as one of our great interests. These aggregate figures show its real significance from an economic point of view. The fact that this business is divided into so many small units on the family farms of the country results in its receiving little concentrated attention. This makes it all the more necessary that the science and practice of the feeding, breeding, and management of poultry be wrought out by public departments and experiment stations. Leaders in poultry departments in our State colleges and agricultural high schools need no longer be backward in assuming the importance of the needed public work in the interests of poultry. The achievements in education and research with poultry at the Rhode Island, New York, Maine, and other experiment stations show that public money spent under wise direction will enable our agricultural colleges and experiment stations to assist most profitably in the production of poultry.

James L. Reid, Breeder of Corn.

The death of James L. Reid, of East Lynn, Taswell County, Illinois, which occurred recently, has removed a highly useful man, one whose services were rendered in the simple, patient way peculiar to so many noble characters who, having found their work, pursue it singlemindedly, quietly, and perseveringly. Mr. Reid took up the improvement of corn in 1846, a time when the word plant breeder was not used as frequently as now, nor with the same peculiar significance. Mr. Reid had devoted his lifetime to the creation of the variety of yellow corn which now bears his name. He gave the world a fixed, prepotent, and characteristic variety of yellow corn. The value of his service cannot well be computed in exact sums of money, but that farming in

the great corn belt has been benefited in a material way, is realized by all who know the importance of the corn crop in American agriculture.

Breeding Poultry for Egg Production.

There is always a strong impulse on the part of many poultry breeders to attend too exclusively to markings of color, and to form. These are valuable identifying characters in pure-bred fowls, but sometimes the egg-laying power, the thickness of meat on breast and legs, and also early maturity and other utility characters receive too little attention. An idea has come from Australia to the American Breeders Association of a plan for use by State fairs, experiment stations, agricultural colleges, and agricultural high schools in encouraging the breeding of chickens with high egg-producing ability. The memorandum below was designed as a suggestion for the board of managers of the Minnesota State Fair. It would seem quite as valuable a suggestion for other State fairs and even more especially for experiment stations, agricultural colleges, and agricultural high schools, and is therefore presented herewith:

PRIZES FOR COMPETITION IN EGG PRODUCTION.

Prizes open to the world are offered for pens of chickens which make the best annual record of production of eggs.

The time of beginning the test shall be August 15, and the time of closing shall be the same date of the succeeding year.

Pullets shall be not more than six months old and hens shall be not less than fourteen months old at the time of entering upon the contest.

A pen shall consist of six females and one male.

Group I.	For pen of hens producing largest number of eggs (averaging 2 ounces each)	$50
II.	For pen of pullets producing largest number of eggs	50
III.	For pen of hens producing greatest profit above cost of feed	50
IV.	For pen of pullets producing greatest profit above cost of feed	50

Entries will be closed one month before the beginning of the tests, that suitable pens and runs may be provided for all entries. The management will provide for the housing, care, and feeding of the pens of fowls and will prescribe a uniform plan of feeding for the several pens. All hens will be trap-nested and individual egg records will be kept, including the weight of the eggs. In addition, an accurate account will be kept of the value of all food used and of the number and value of all eggs laid by each pen and of all other factors which enter into the competition.

The fowls shall be left for exhibition at the State fair (or other show) following the completion of the contest.

A cock or cockerel suited to the production of pure-bred chicks of the same breed must accompany each pen of females. The eggs laid by the hens shall become the property of the State board of agriculture (college, or other organization in charge) and may be sold for breeding purposes at customary prices for pure-bred eggs.

Entries must be made at least a month before the date of beginning of the contest. Unless at least ten pens are entered, the management reserves the right not to proceed with this contest, and unless more than one entry is made in a group the management will not start that group for the contest.

The minimum age at the beginning of the contest will of necessity be chosen to meet the conditions as affected by the time of the year chosen for opening and closing the contest. Experience may dictate a change in the date at first chosen. Pullets usually begin laying at about six months of age. Where it is desirable to have the hens start at the same time as the pullets it may be necessary to choose a date on which they can best start into their second year of laying, as in the autumn when they are a year old.

Where the work is done on the grounds of the State or other agricultural fair, the test year may be set to begin a week or two before the opening of the fair. Those visiting the fair can then see the experiment in progress; and the birds which have finished in the previous year's contest can be on exhibition, showing their relative standing at the close of the year's contest. The outgoing pens of fowls can be on exhibition in the general poultry show building, where the details of the contest can be displayed on charts or in other suitable manner.—W. M. HAYS.

Live Stock Shows.

When our local, State and national live stock shows develop comprehensive exhibits showing centgener families of dairy stock, trotting horses, and poultry, these exhibits will have a profound influence in placing the breeding of the classes of live stock named on a statistical basis of individual and centgener values, which will help to lead up to a broader philosophy of breeding meat-producing and work stock.

ASSOCIATION MATTERS

Good Words.

The editors have received many words of commendation, hearty good will, and encouragement upon the appearance and contents of the first number of the *Magazine*. All this is greatly appreciated and will stimulate to renewed effort and faithful service. Here is a thought which each individual member will do well to appropriate: With the intellectual, highly trained, and successful class of men who compose the membership of the Association, and each contributing, the *Magazine* can be brought to an unusually high standard of excellence and can be made very helpful and valuable. Each member should make it his duty to contribute in a way that he thinks will add to the interest and variety of contents of the *Magazine*, and will enlarge its usefulness as a means of intercommunication and as a repository of scientific facts.

Here is what Hon. Wm. George, Vice-President of the Association, says:

> I wish to congratulate you upon the fine appearance of the initial number of the American Breeders Magazine. It certainly needs only a little of your energy and push to make it a success.

Prof. James E. Rice, Cornell University, writes as follows:

> This is to congratulate you on the splendid first issue of the A. B. A. Magazine. From every standpoint it is high grade and unique. This will be a splendid inducement for securing new membership.

An editor's opinion of the *Magazine*—Edwin C. Powell, editor Farm and Home, Springfield, Mass:

> I have looked over the Magazine with much interest. I want to congratulate you on not only the high type of articles but the very readable manner in which they are presented.

Another editor, John B. Conner, of the *Indiana Farmer:*

> We are well pleased with the Magazine.

From W. J. Wright, Assistant Professor of Horticulture, Pennsylvania State College:

Please accept my congratulations for the excellence of Vol. I, No. 1, of the American Breeders Magazine, which has just reached my desk. As a teacher of plant breeding at this institution I shall expect to derive much benefit from its pages.

And we are no little proud and pleased over the following from Prof. Charles E. Bessey, of the University of Nebraska:

I am very much pleased with the appearance of the first number of the American Breeders Magazine. It is well gotten up and the subject matter contained in it is good and I think must prove to be useful.

Bound Reports.

The office of the American Breeders Association is unable to fill any orders for back volumes of the Annual Report, except Volume IV. These may be had at $2 per volume. There is a constant call from new members for back numbers of the Report, and we are obliged to disappoint these many inquirers. Old members who happen to have spare copies of the earlier reports which they care to dispose of are requested to give the Secretary their names and addresses and number of the volume for sale.

Association Publications.

Libraries desiring to keep complete sets of the publications of the American Breeders Association will find it greatly to their advantage to take life memberships in the Association. The Secretary has on file a number of applications from libraries, for back volumes, which can be filled only with difficulty and will probably require considerable time. With the addition of the Eugenics Section the publications will assume a larger importance and command a wider interest than ever before, and will be valuable additions to general libraries.

Members are requested to be prompt in notifying the Secretary of changes of address, and it is suggested that city addresses be given complete as to street and number.

The delay in sending out the programs for the last annual meeting, held at Omaha, Neb., was due to the fact that several members

Send in Titles of Papers.

were slow in sending in the titles of their papers. It is very desirable to avoid this embarrassing situation this year. The programs of our annual meetings display very advantageously the strong features of our organization and the immense scope of its work. Moreover, an interesting program, sent out in ample time for the recipients to make preparations to attend the meeting, may be instrumental in securing a large attendance. Notwithstanding the fact that the Association cannot complain on that score, as all meetings have been well attended heretofore, we must constantly strive for larger possibilities; while a fair attendance is good, a big attendance is still more desirable. Hence the Secretary suggests that members having papers in course of preparation should send in the titles as early as it can conveniently be done.

The New Eugenics Section.

At the Sixth Annual Meeting of the American Breeders Association, following a suggestion communicated by the secretary of the Committee on Eugenics, Dr. C. B. Davenport, Professor N. E. Hansen gave notice of a proposition to change the Constitution of the Association to raise the Committee on Eugenics to a third section coordinate with the Plant Section and the Animal Section. On April 26 the Council voted to submit this proposed change to a vote of the membership. Accordingly, the Secretary mailed a vote to the members on June 2 and on July 1 the vote was counted, Mr. C. W. Warburton, Dr. C. G. Palmer, and Mr. Nat. C. Murray acting as tellers, and certifying the vote. It stood 499 for the change and 5 against, and notice of the change is hereby given.

Constitution of the Association.

From the time of the meeting in December, when the matter of submitting the change of Constitution was brought up, until a vote by the members of the Association was obtained, the printing of the Constitution of the Association was held in abeyance, although many requests have come to the Secretary's office, especially from new members, for copies of the Constitution and By-laws.

The amendment having carried, the Constitution as printed herewith is brought up to date, and between the covers of the *Magazine* is in permanent and handy form for reference.

CONSTITUTION.

ARTICLE I.—*Name.*—The name of this Association shall be the American Breeders Association.

ARTICLE II.—*Purposes.*—The purpose of this Association shall be to study the laws of breeding and to promote the improvement of plants and animals by the development of expert methods of breeding.

ARTICLE III.—*Membership.*—The annual membership shall consist of persons, societies and institutions interested in the objects of this Association and paying the prescribed annual fee. There shall also be life members, who shall have paid a fee of twenty dollars; patrons, who shall have made a gift to the Association of the value of one thousand dollars or more; and honorary members.

The names of patrons shall be retained in the lists of patrons as long as the Association exists. Any person who shall have done notable service in advancing the objects of the Association may be elected an honorary member by the Council. No more than two honorary members may be elected in any one year, and there shall be no more than ten honorary members.

Honorary members, life members and patrons shall be exempt from annual dues.

ARTICLE IV.—*Organization.*—The officers shall be a President, a Vice-President, a Secretary and a Treasurer. An honorary President may be chosen at any annual meeting.

There shall be a Plant Section, an Animal Section and a Eugenics Section, each with its Chairman and its Secretary.

There shall be a Council of nine members, which shall have charge of the affairs of the Association when it is not in session and during its meetings shall be at the command of the Association. The Vice-President, the Secretary, the Treasurer, and the Chairmen and Secretaries, of the Plant Section, of the Animal Section and the Eugenics Section shall be ex-officio the nine members of the Council.

Any action taken by any section relating to the public policy of the Association, to become operative must be approved by the general association.

ARTICLE V.—*The Council.*—All resolutions and all amendments to the Constitution and By-Laws shall be submitted to or referred to the Council and approved by them before they may properly come before the Association.

ARTICLE VI.—*Meetings.*—A meeting of the Association shall be held annually at such time and place as may be determined by the Council.

ARTICLE VII.—*Elections.*—Election of officers for the ensuing year shall be held the last day of the annual meeting, and such election shall be by ballot.

ARTICLE VIII.—*Amendments.*—Amendments to this Constitution may be made by a majority of the Council with the concurrence of two-thirds of the members of the Association voting upon the question by mail within thirty days after the notice is mailed by the Secretary, providing that the amendment shall have been discussed in general sessions at the previous annual meeting, and that printed notice shall have been given to the entire membership.

By-Laws.

Section I.—*Membership.*—The active members shall be: *First,* delegates of societies of plant and animal breeders, horticultural societies, agricultural societies, biological societies, of colleges, universities or experiment stations, or of other organizations interested in the objects of this Association; *Second,* plant and animal breeders and those interested in the improvement of plants and animals, or in investigations or instruction relating thereto, and other persons interested in the purposes of this Association. The Council shall determine the eligibility of the applicant. Application for membership shall be made to the Secretary on a printed form furnished by the Secretary.

Section II.—*Privileges of Members.*—All classes of members shall be entitled to vote. Each member is entitled to one copy of the annual report issued by the Association.

Section III.—*Delegate Membership.*—Librarians of institutions and secretaries of societies, in their official titles, may become members and receive publications, and their official addresses may appear in the list of addresses of members.

Section IV.—*Dues.*—The membership dues of persons, of societies and of institutions shall be two dollars and shall be payable upon notification of election and annually thereafter.

Section V.—*Arrears.*—A member in arrears over one year shall cease to be an active member, but may be restored by paying all arrears.

Section VI.—*Officers.*—The officers shall perform such services as are ordinarily required by their positions and shall serve until the election of their successors.

Section VII.—*The President.*—The President shall serve for one year, shall preside over the annual meetings for which he is elected and shall give the annual address.

Section VIII.—*The Vice-President.*—The Vice-President shall serve for one year and shall preside in the absence of the President.

Section IX.—*The Treasurer.*—The Treasurer shall serve for two years, shall receive and hold all moneys coming to the Association, and shall disburse or invest as Trustee all moneys as directed by a majority vote of the Council, and shall keep an accurate and detailed account of all receipts and disbursements and make a report of the same to the Council at or before each annual meeting, and a summarized report shall be furnished the Council, which shall be made to the annual meeting. The records and accounts of the Treasurer shall be open to the inspection of members. The Council shall require a suitable bond of the Treasurer.

Section X.—*The Secretary.*—The Secretary shall be the executive officer of the Association, acting under the direction of the Council. He shall keep a record of all proceedings of the Association and of the Council, of membership dues and miscellaneous receipts collected, and pay all moneys received and all balances promptly to the Treasurer. He shall arrange with local committees for the annual meetings, send notices, receive, record and hold in trust property of the Association other than investments and funds in the hands of

the Treasurer, arrange for the printing and distributing of reports and other printed matter, procure all material and assistance required in the prosecution of these duties and perform all other duties delegated to him by the Council.

SECTION XI.—*Duties of the Council.*—The Council shall appoint committees of its members or of the Association, shall control the presentation, discussion and publication of papers, shall determine upon the place and time of the annual and special meetings, shall arrange through the Secretary for local committees to receive and entertain the Association, shall examine the reports and accounts of all officers and committees and shall pass upon all other business not transacted by the society. The meetings of the Council shall be called by the Chairman, through the Secretary.

Six members present, or voting by mail, shall constitute a quorum and a majority vote shall determine all questions. At its annual meeting the Council shall hear the reports of the Treasurer, of the Secretary and of committees and shall transact other necessary business. The Council may vote by mail ballot upon questions submitted to them by the Secretary, voting for or against, or to refer to the Council at its next meeting.

SECTION XII.—*Meetings.*—The Annual Meetings are to be called by the President on the approval of the Council.

SECTION XIII.—*Publications.*—The annual reports are to be edited by the Secretary, assisted by the Secretaries of the Plant, Animal and Eugenics Sections.

SECTION XIV.—*Committees.*—The Council with the concurrence of the Association may organize committees to bring about co-operation and to deal with such subjects as it may deem important. These committees, besides considering the general features of their respective subjects, shall annually report upon the progress of work in specific subjects, work in foreign countries, etc.

SECTION XV.—*Sectional Meetings.*—The Council, in making up the program for the annual meeting, shall so apportion the subjects for discussion to the general session, to the Animal Section, to the Plant Section and to the Eugenics Section as shall best serve the interests of all members.

SECTION XVI.—*Amendments.*—Amendments to the By-Laws, upon recommendation of the Council, may be made by a majority vote of the Association.